



# **CERTIFICATION**

I, Kenichi Hori, being duly qualified to translate from the Japanese language to the English language, hereby certify that I have translated the attached document, Japanese Patent Application No. 2000-294074, filed in the Japanese Patent Office September 27, 2000, from the Japanese to the English language, and that the attached document is a true and correct translation of said Japanese document.

Date: Dec. 13, 2002

A handwritten signature in black ink, appearing to read "Kenichi Hori", written over a horizontal line.

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**[DOCUMENT NAME]** SPECIFICATION

**[TITLE OF THE INVENTION]** PRINTING UP TO EDGES OF PRINTING  
PAPER WITHOUT PLATEN SOILING

**[SCOPE OF CLAIM FOR PATENT]**

[Claim 1] A dot-recording device for recording ink dots on a surface of a print medium with the aid of a dot-recording head provided with a plurality of dot-forming elements for ejecting ink droplets, the dot-recording device comprising:

10 a main scanning unit configured to drive the dot-recording head and/or the print medium to perform main scanning;

a head driver configured to drive at least some of the dot-forming elements to form dots during the main scanning;

15 a platen configured to extend in the main scanning direction and to be disposed opposite the dot-forming elements at least along part of a main scan path, and the platen being configured to support the print medium at a position opposite the dot-recording head;

a sub-scanning unit configured to move the print medium to perform sub-scanning in between the main scans; and

20 a controller configured to control the dot recording device, and wherein the platen has a slot extending in the main scanning direction at a position opposite dot-forming elements disposed on at least one edge of both edges in the sub-scanning direction, and

the controller has:

25 (a) a first recording mode to effect printing near an edge of the printing medium, in the first recording mode the controller performing edge printing by ejecting ink droplets from at least some of the dot-forming elements disposed opposite the slot when the print medium is supported on the platen, and the edge of the print medium is disposed above the slot, and

(b) a second recording mode to effect printing in an intermediate portion of

the print medium, a maximum sub-scan feed amount in the second recording mode being greater than a maximum sun-scan feed amount in the first recording mode.

[Claim 2] A dot-recording device as defined in Claim 1, wherein the controller prevents ink droplets from being ejected by dot-forming elements other than the dot-forming elements disposed opposite the slot during the edge printing.

[Claim 3] A dot-recording device as defined in Claim 1, wherein the slot is disposed at a position opposite a dot-forming element that is located at a downstream edge in the sub-scanning direction; and

the controller performs the edge printing when a front edge of the print medium is disposed above the slot.

[Claim 4] A dot-recording device as defined in Claim 1 or 3, wherein the slot is disposed at a position opposite a dot-forming element that is located at an upstream edge in the sub-scanning direction; and

the controller performs the edge printing when a rear edge of the print medium is disposed above the slot.

[Claim 5] A dot-recording device as defined in Claim 1, wherein the sub-scanning unit comprises:

an upstream sub-scanning unit configured to hold and move the print medium, the upstream sub-scanning unit being disposed on an upstream side in the sub-scanning direction with respect to the dot-recording head; and

a downstream sub-scanning unit configured to hold and move the print medium, the downstream sub-scanning unit being disposed on a downstream side in the sub-scanning direction with respect to the dot-recording head.

[Claim 6] A dot-recording device as defined in Claim 1, wherein the sub-scanning of the first recording mode is performed in a feed amount corresponding to a single dot pitch in the sub-scanning direction.

[Claim 7] A dot-recording device as defined in Claim 1, wherein the

controller performs the edge printing on the basis of image data representing an image extending outside the print medium beyond the edge on which the edge printing is performed.

[Claim 8] A dot-recording device as defined in Claim 7, wherein a length of  
5 an area of the image outside the print medium is set less than the slot width.

[Claim 9] A dot-recording method using a dot-recording device for recording ink dots on a surface of a print medium, the dot-recording device including a dot-recording head having a plurality of dot-forming elements for ejecting ink droplets, the dot-recording device comprising a platen configured to  
10 extend in the main scanning direction and to be disposed opposite the dot-forming elements at least along part of a main scan path, the platen being configured to support the print medium at a position opposite the dot-recording head, and that has a slot extending in the main scanning direction at a position opposite dot-forming elements disposed on at least one edge of both edges in  
15 the sub-scanning direction, and the method comprising the steps of:

(a) effecting printing near an edge of the printing medium in a first recording mode, in the first recording mode the controller performing edge printing by ejecting ink droplets from at least some of the dot-forming elements disposed opposite the slot when the print medium is supported on the platen,  
20 and the edge of the print medium is disposed above the slot, wherein the dot-recording method further comprises

(b) effecting printing in an intermediate portion of the print medium in a second recording mode, a maximum sub-scan feed amount in the second recording mode being greater than a maximum sun-scan feed amount in the first  
25 recording mode.

[Claim 10] A print control device for generating print data to be sent to a dot-recording unit that records ink dots on a surface of a print medium, the dot-recording unit including:  
a main scanning unit configured to drive the dot-recording head and/or the print

medium to perform main scanning;

a head driver configured to drive at least some of the dot-forming elements to form dots during the main scanning;

5 a platen configured to extend in the main scanning direction and to be disposed opposite the dot-forming elements at least along part of a main scan path, and the platen being configured to support the print medium at a position opposite the dot-recording head;

a sub-scanning unit configured to move the print medium to perform sub-scanning in between the main scans; and

10 a controller configured to control the dot recording device, and wherein the platen has a slot extending in the main scanning direction at a position opposite dot-forming elements disposed on at least one edge of both edges in the sub-scanning direction, and the print control device comprising:

15 an image data generator for generating image data for an area outside the print medium beyond the edge on which the edge printing is performed.

[Claim 11] A computer readable medium for storing a computer program product for recording ink dots on a surface of a print medium using a computer, the computer equipped with a dot-recording device for recording ink dots on the surface of a print medium with the aid of a dot-recording head provided with a plurality of dot-forming elements for ejecting ink droplets, the dot-recording device comprising:

20 a platen configured to extend in the main scanning direction and to be disposed opposite the dot-forming elements at least along part of a main scan path, and the platen being configured to support the print medium at a position opposite the dot-recording head, and being configured to have a slot extending in the main scanning direction at a position opposite dot-forming elements disposed on at least one edge of both edges in the sub-scanning direction; the computer readable medium comprising:

an image data generating program for causing the computer to generate

image data for an area outside the print medium beyond the edge on which the edge printing is performed.

## **[DETAILED DESCRIPTION OF THE INVENTION]**

[0001]

### **5 [Field of the Invention]**

The present invention relates to a technique for recording dots on the surface of a recording medium with the aid of a dot-recording head, and more particularly to a technique for printing images up to the edges of printing paper without soiling the platen.

10 [0002]

### **[Description of the Prior Art]**

Printers in which ink is ejected from the nozzles of a print head have recently become popular as computer output devices. Fig. 30 is a side view depicting the periphery of a print head for a conventional printer. Printing paper P is supported on a platen 26o while facing the head 28o. The printing paper P is fed in the direction of arrow A by the upstream paper feed rollers 25p and 25q disposed upstream of the platen 26o and by the downstream paper feed rollers 25r and 25s disposed downstream of the platen 26o. Dots are recorded and images printed on the printing paper P when ink is ejected from the head.

20 [0003]

### **[Problems to be solved by the Invention]**

When an attempt is made to print images up to the edges of printing paper with the aid of such a printer, it is necessary to arrange the printing paper such that the edges of the printing paper are disposed underneath the print head (that is, on the platen) and to cause ink droplets to be ejected from the print head. With such printing, however, the ink droplets sometimes miss the edges of the printing paper (for which the droplets have been originally intended) and end up depositing on the platen due to errors developing during the feeding of the printing paper, a shift in the impact location of the ink droplets, or the like. In



such cases, the ink deposited on the platen soils the printing paper transported over the platen in the next step.

[0004]

It is an object of the present invention, which was perfected in order to overcome the above-described shortcomings of the prior art, to provide a technique that allows images to be printed up to the edges of printing paper while preventing ink droplets from depositing on the platen.

[0005]

**[Means for Solving the Problem and its Function/Effect]**

Perfected in order to at least partially overcome the above-described shortcomings, the present invention envisages performing specific procedures for a dot-recording device designed to record ink dots on a surface of a print medium with the aid of a dot-recording head provided with a plurality of dot-forming elements for ejecting ink droplets. The dot-recording device comprises a platen configured to extend in the main scanning direction and to be disposed opposite the dot-forming elements at least along part of a main scan path, the platen being configured to support the print medium, a width of the slot in the sub-scanning direction corresponding to a specific sub-scanning range on a surface of the dot recording head including at least part of the plurality of dot-forming elements.

[0006]

The printing (dot-forming) procedure performed by such a printing device entails driving the dot-recording head and/or the print medium to perform main scanning, driving at least some of the dot-forming elements to form dots, and causing the print medium to undergo sub-scanning by being driven across the main scanning direction in between the main scans. In the process, printing near an edge of the printing medium is effected in a first recording mode, in the first recording mode the controller performing edge printing by ejecting ink droplets from at least some of the dot-forming elements disposed opposite the

slot when the print medium is supported on the platen, and the edge of the print medium is disposed above the slot. Printing in an intermediate portion of the print medium is effected in a second recording mode, a maximum sub-scan feed amount in the second recording mode being greater than a maximum sun-scan  
5 feed amount in the first recording mode.

[0007]

According to this embodiment, ink droplets can be prevented from depositing on the plate, and areas extending all the way to the edges of printing paper can be printed without blank spaces with the aid of dot-forming elements  
10 disposed opposite the slot.

[0008]

The edge portions should preferably be printed such that the ink droplets are prevented from being ejected by any dot-forming elements other than those disposed opposite the slot. Adopting this embodiment makes it possible to  
15 prevent ink droplets from soiling the platen when the preceding portion of the print medium is insufficiently fed in the sub-scanning direction and the front edge of the print medium being printed fails to reach the position above the slot; that is, when the front edge of the print medium rests on the platen, and part of the platen is disposed directly opposite the dot-recording head. The same applies  
20 to cases in which the print medium is fed in the sub-scanning direction in an excessive manner and the rear edge of the print medium passes beyond the slot when images are printed on the rear edge of the print medium.

[0009]

Images should preferably be printed in the edge portions when the front  
25 edge of the print medium is above the slot in cases in which the slot is provided at a position opposite at least a dot-forming element that is disposed along a downstream edge in the sub-scanning direction. Such an embodiment allows images to be printed without blank space along the front edge of the print medium.

[0010]

In addition, images should preferably be printed in the edge portions when the rear edge of the print medium is above the slot opening in cases in which the slot is provided at a position opposite at least a dot-forming element that is disposed along an upstream edge in the sub-scanning direction. Such an embodiment allows images to be printed without blank spaces along the rear edge of the print medium.

[0011]

The following benefits are obtained when dots are recorded in this manner in accordance with an embodiment in which the sub-scanning unit for performing sub-scanning in a printing device comprises an upstream sub-scanning unit configured to hold and move the print medium, the upstream sub-scanning unit being disposed on an upstream side in the sub-scanning direction with respect to the dot-recording head; and a downstream sub-scanning unit configured to hold and move the print medium, the downstream sub-scanning unit being disposed on a downstream side in the sub-scanning direction with respect to the dot-recording head.

[0012]

In the above-described printing device, sub-scanning is accomplished solely with the upstream or downstream sub-scanning unit when images are printed in the edge portions of a print medium. According to the printing procedure adopted for this printing device, the printing distance can be reduced by accomplishing sub-scanning solely with the upstream or downstream sub-scanning unit.

[0013]

The sub-scanning of the first recording mode should preferably be performed in a feed amount corresponding to a single dot pitch in the sub-scanning direction. Adopting this arrangement makes it possible to print images in the edge portions of the recording medium with nozzles that are close

to the edge portions in the sub-scanning direction in the dot-recording head.

[0014]

Such printing should preferably involve generating image data representing an image extending outside the print medium beyond the edge on which the edge printing is performed, and forming dots on the basis of these image data. Adopting this arrangement makes it possible to print images on the portions of the print medium extending beyond the intended position on the basis of images provided for an area outside the print medium even when the print medium is positioned incorrectly.

[0015]

A length of an area of the image outside the print medium is preferably set less than the slot width. According to this arrangement, the print medium can be positioned relative to the dot-recording head such that the ink droplets for recording images in an area beyond the edge portion on which images are printed in accordance with the edge-portion printing routine adopted for the print medium are caused to descend into the slot when these ink droplets fail to deposit on the print medium.

[0016]

The present invention can be implemented as the following embodiments.

- (1) A dot-recording method, print control method, or printing method.
- (2) A dot-recording device, print control device, or printing device.
- (3) A computer program for operating the device or implementing the method.
- (4) A storage medium containing computer programs for operating the device or implementing the method.
- (5) A data signal carried by a carrier wave and designed to contain a computer program for operating the device or implementing the method.

[0017]

#### **[Description of the Preferred Embodiments]**

Embodiments of the present invention will now be described through embodiments in the following sequence.

A. Overview of Embodiments

B. First Embodiment

5 C. Second Embodiment

D. Third Embodiment

E. Embodiment With Lateral Slot

F. Modifications

[0018]

10 A. Overview of Embodiments

Fig. 1 is a side view depicting the structure of the periphery of a print head for an ink-jet printer configured according to an embodiment of the present invention. In Fig. 1, printing paper P is supported and fed (in the sub-scanning direction) by upstream paper feed rollers 25a and 25b, and the front edge Pf thereof passes over an upstream slot 26f and a platen 26, reaching an opening above a downstream slot 26r. At this point, ink droplets Ip are ejected from the print head 28, and printing is started. Even when the paper is fed incorrectly, images can be printed up to the edges without leaving blank spaces on the front-edge portion Pf of the printing paper P because printing is started when the front edge Pf of the printing paper P has moved beyond nozzle No. 1. The ink droplets not deposited on the printing paper P are absorbed by an absorbent member 27r.

[0019]

Printing should preferably be carried out by repeatedly scanning the medium in the sub-scanning direction in small feed-per-dot increments when images are printed near the front edge Pf of the printing paper P. This approach makes it easier to print images in the area containing the front edge of the printing paper above the downstream slot 26r.

[0020]

Fig. 2 depicts the manner in which images are printed on the rear edge Pr of the printing paper P. In Fig. 2, printing paper P is supported and fed solely by downstream paper feed rollers 25c and 25d, and the rear edge Pr thereof reaches the opening above the downstream slot 26r in the final stages of printing.

5 At this point, ink droplets are ejected from the print head 28, and images are printed in the area containing the rear edge of the printing paper. Even when the paper is fed incorrectly, images can be printed up to the edges without leaving blank spaces on the rear-edge portion Pr of the printing paper because printing is performed when the rear edge Pr of the printing paper P has not yet  
10 reached nozzle No. 8. The ink droplets not deposited on the printing paper P are absorbed by an absorbent member 27f.

[0021]

Printing should preferably be carried out by repeatedly scanning the medium in the sub-scanning direction in small increments when images are  
15 printed near the rear edge Pr of the printing paper. This approach makes it easier to print images in the area containing the rear edge of the printing paper above the upstream slot 26f.

[0022]

## B. First Embodiment

### 20 (1) Device Structure

Fig. 3 is a block diagram depicting the structure of an image processing device and a printing device as embodiments of the present invention. A scanner 12 and a printer 22 are connected to a computer 90 in the manner shown in the drawing. In addition to being able to function as an image  
25 processing device, the system can function as a printing device in conjunction with the printer 22 as a result of the fact that specific programs are loaded and executed by the computer 90. The following units are connected to each other by a bus 80 in the computer 90, which is based on a CPU 81 for performing arithmetic processing in order to control various routines related to image

processing in accordance with the programs: ROM 82 is used to store data processing software or the data to be processed by the CPU 81, and RAM 83 is a memory designed to temporarily store data processing software or the data to be processed. The input interface 84 is used to enter signals from the scanner 12 or keyboard 14, and the output interface 85 is used to output data to the printer 22. The CRTC 86 is used to control signal output for a CRT 21 capable of displaying information in color, and the disk controller (DDC) 87 is designed to control data exchange involving a hard disk 16, floppy drive 15, or CD-ROM drive (not shown). The hard disk 16 contains the programs to be loaded and executed by the RAM 83, various types of software provided in the form of device drivers, and the like.

[0023]

A serial input/output interface (SIO) 88 is also connected to the bus 80. The SIO 88 is connected to a modem 18, and to a public telephone network PNT via this modem 18. The computer 90 is connected to an external network through the agency of the SIO 88 and modem 18, and a connection to a specific server SV allows image processing software to be downloaded to the hard disk 16. The required software can also be copied from a floppy disk FD or CD-ROM and executed by the computer 90.

[0024]

Fig. 4 is a block diagram depicting the structure of the software for the present printing device. In the computer 90, an application program 95 is executed within the framework of a specific operating system. The operating system contains a video driver 91 or a printer driver 96, and the application program 95 outputs the image data D to be transferred to the printer 22 by means of these drivers. The application program 95 for performing video retouching or the like allows images to be read from the scanner 12 and displayed by the CRT 21 by means of the video driver 91 while processed in a prescribed manner. The data ORG presented by the scanner 12 are in the

form of primary-color image data ORG obtained by reading a color original and composed of the following three color components: red (R), green (G), and blue (B).

[0025]

5       When the application program 95 generates a printing command, the printer driver 96 of the computer 90 receives image data from the application program 95, and the resulting data are converted to a signal that can be processed by the printer 22 (in this case, into a signal containing multiple values related to the colors cyan, magenta, light cyan, light magenta, yellow, and black).

10      In the example shown in Fig. 5, the printer driver 96 comprises a resolution conversion module 97, a color correction module 98, a halftone module 99, and a rasterizer 100. A color correction table LUT and a dot-forming pattern table DT are also stored. The application program 95 corresponds to the image data generator.

15       [0026]

20       The role of the resolution conversion module 97 is to convert the resolution of the color image data handled by the application program 95 (that is, the number of pixels per unit length) into a resolution that can be handled by the printer driver 96. Because the image data converted in terms of resolution in this manner are still in the form of video information composed of three colors (RGB), the color correction module 98 converts these data into the data for each of the colors (cyan (C), magenta (M), light cyan (LC), light magenta (LM), yellow (Y), and black (K)) used by the printer 22 for individual pixels while the color correction table LUT is consulted.

25       [0027]

      The color-corrected data have a gray scale with 256 steps, for example. The halftone module 99 executes a halftone routine for expressing this gray scale in the printer 22 by forming dispersed dots. The halftone module 99 executes the halftone routine upon specifying the dot formation patterns of the



corresponding ink dots in accordance with the gray scale of the image data by consulting the dot-forming pattern table DT. The image data thus processed are sorted according to the data sequence to be transferred to the printer 22 by the rasterizer 100, and are outputted as final print data PD. The print data PD  
5 contain information about the amount of feed in the sub-scanning direction and information about the condition of dot recording during each main scan. In the present embodiment, the sole role of the printer 22 is to form ink dots in accordance with the print data PD without processing the images, although it is apparent that such processing can also be carried out by the printer 22.

10 [0028]

The overall structure of the printer 22 will now be described with reference to Fig. 5. As can be seen in the drawing, the printer 22 comprises a mechanism for transporting paper P with the aid of a paper feed motor 23; a mechanism for reciprocating a carriage 31 in the axial direction of the platen 26 with the aid of a  
15 carriage motor 24; a mechanism for actuating the print head 28 mounted on the carriage 31 and ejecting the ink to form ink dots; and a control circuit 40 for exchanging signals between the paper feed motor 23, the carriage motor 24, the print head 28, and a control panel 32.

[0029]

20 The mechanism for reciprocating the carriage 31 in the axial direction of the platen 26 comprises a sliding shaft 34 mounted perpendicular to the axial direction of the platen 26 and designed to slidably support the carriage 31, a pulley 38 for extending an endless drive belt 36 from the carriage motor 24, a position sensor 39 for sensing the original position of the carriage 31, and the  
25 like.

[0030]

The carriage 31 can support a cartridge 71 for black ink (K) and a color-ink cartridge 72 containing inks of the following six colors: cyan (C), light cyan (LC), magenta (M), light magenta (LM), and yellow (Y). A total of six ink-ejecting

heads 61 to 66 are formed in the print head 28 in the bottom portion of the carriage 31, and introduction tubes 67 for guiding the ink from the ink tank to each color head are provided to the bottom portion of the carriage 31. Mounting the cartridge 71 for the black (K) ink and the cartridge 72 for the color inks on the carriage 31 causes the introduction tubes 67 to enter the connection holes provided to each cartridge and allows the ink to be fed from the ink cartridges to the ejection heads 61 to 66.

[0031]

The color heads 61 to 66 in the bottom portion of the carriage 31 are provided with 48 nozzles Nz for each color, and each nozzle is provided with a highly responsive piezoelectric (electrostrictive) element PE. The piezoelements PE are disposed at locations adjacent to the ink conduits for guiding the ink to the nozzles Nz. As is well known, a piezoelement PE changes its crystal structure under the application of voltage and very rapidly converts electrical energy to mechanical energy. In the present embodiment, applying a voltage for a prescribed period between the electrodes disposed at both ends of a piezoelement PE causes the piezoelement PE to expand during the application of voltage, and deforms the lateral wall of the corresponding ink conduit. As a result, the volume of the ink conduit 68 decreases in accordance with the expansion of the piezoelement PE, the ink forms particles Ip in proportion to this contraction, and the particles are ejected at a high speed from the tip of the corresponding nozzle Nz. Images are printed as a result of the fact that the ink particles Ip penetrate into the paper P mounted on the platen 26.

[0032]

Fig. 6 is a diagram depicting the arrangement of the ink-jet nozzles Nz in the ink-ejecting heads 61–66. These nozzles form six nozzle arrays for ejecting the ink of each color (black (K), cyan (C), light cyan (LC), magenta (M), light magenta (LM), and yellow (Y)), and the 48 nozzles of each array form a single row at a constant pitch k. Nozzle pitch is a value equal to the number of raster

lines (that is, pixels) accommodated by the interval between the nozzles on the print heads in the sub-scanning direction. For example, nozzles whose intervals correspond to three interposed raster lines have a pitch  $k$  of 4.

[0033]

5        Fig. 7 is a plan view depicting the periphery of the platen 26. The width of the platen 26 in the sub-scanning direction is greater than the maximum width of the printing paper  $P$  that can be accommodated by the printer 22. Upstream paper feed rollers 25a and 25b are provided upstream of the platen 26. Whereas the upstream paper feed roller 25a is a single drive roller, the upstream  
10    paper feed roller 25b comprises a plurality of freely rotating small rollers. Downstream paper feed rollers 25c and 25d are also provided downstream of the platen. The downstream paper feed roller 25c comprises a plurality of rollers on a drive shaft, and the downstream paper feed roller 25d comprises a plurality of freely rotating small rollers. Slots parallel to the axis of rotation are  
15    formed in the external peripheral surface of the downstream paper feed roller 25d. Specifically, the downstream paper feed roller 25d has radial teeth (portions between slots) in the external peripheral surface thereof and appears to be shaped as a gear when viewed in the direction of the axis of rotation. The downstream paper feed roller 25d is commonly referred to as a milled roller and  
20    is designed to press the printing paper  $P$  against the platen 26. The downstream paper feed roller 25c and upstream paper feed roller 25a rotate synchronously at the same peripheral speed.

[0034]

25        The print head 28 moves back and forth in the main scanning direction over the platen 26 sandwiched between the upstream paper feed rollers 25a and 25b and the downstream paper feed rollers 25c and 25d. The printing paper  $P$  is held by the upstream paper feed rollers 25a and 25b and the downstream paper feed rollers 25c and 25d, and an intermediate portion thereof is supported by the upper surface of the platen 26 while disposed opposite the rows of

nozzles in the print head 28. The paper is fed in the sub-scanning direction by the upstream paper feed rollers 25a and 25b and the downstream paper feed rollers 25c and 25d, and images are sequentially recorded by the ink ejected from the nozzles of the print head 28. In the present claims, the upstream paper feed rollers 25a and 25b are referred to as an upstream sub-scanning unit, and the downstream paper feed rollers 25c and 25d as a downstream secondary drive/scan unit.

[0035]

The platen 26 is provided with an upstream slot 26f and a downstream slot 26r, which are located on the upstream and downstream sides, respectively, in the sub-scanning direction. The width of the upstream slot 26f or downstream slot 26r in the main scanning direction is greater than the maximum width of the printing paper P that can be accommodated by the printer 22. In addition, absorbent members 27f and 27r for accepting and absorbing ink droplets Ip are disposed in the bottom portions of the upstream slot 26f and downstream slot 26r, respectively. The downstream slot 26r is disposed opposite those nozzles Nz of the print head 28 that form a downstream group of nozzles Nr (the hatched group of nozzles in Fig. 7) containing the extreme downstream nozzle. The upstream slot 26f is disposed opposite those nozzles of the print head 28 that form an upstream group of nozzles Nf (not shown in Fig. 7) containing the extreme upstream nozzle. The printing paper P passes over the openings of the upstream slot 26f and downstream slot 26r when fed in the sub-scanning direction by the upstream paper feed rollers 25a and 25b and the downstream paper feed rollers 25c and 25d.

[0036]

The inner structure of the control circuit 40 (see Fig. 5) belonging to the printer 22 will now be described. The control circuit 40 contains the following units in addition to CPU 41, PROM 42, and RAM 43: a PC interface 45 for exchanging data with the computer 90, a drive buffer 44 for outputting the ON

and OFF signals of the ink jet to the ink-ejecting heads 61–66, and the like. These elements and circuits are connected together by a bus. The control circuit 40 receives the dot data processed by the computer 90, temporarily stores them in the RAM 43, and outputs the results to the drive buffer 44 according to specific timing.

[0037]

In the printer 22 thus configured, the carriage 31 is reciprocated by the carriage motor 24 while paper P is transported by the paper feed motor 23, the piezoelement of each of the nozzle units belonging to the print head 28 is actuated at the same time, ink droplets  $lp$  of each color are ejected, and ink dots are formed to produce multicolored images on the paper P.

[0038]

In the printer of the present embodiment, the areas near the top and lower edges of printing paper are printed differently from the intermediate area of the printing paper because the upper edge  $Pf$  of the printing paper P is printed over the downstream slot 26r, and the lower edge  $Pr$  is printed over the upstream slot 26f. In the present specification, the routine whereby images are printed in the intermediate area of printing paper will be referred to as an "intermediate routine," the routine whereby images are printed in the area near the upper edge of printing paper will be referred to as an "upper-edge routine," and the routine whereby images are printed in the area near the lower edge of printing paper will be referred to as a "lower-edge routine." In addition, when referring both the upper-edge routine and lower-edge routine, they will be referred to as an "upper- or lower-edge routine".

[0039]

The width of the upstream slot 26f and downstream slot 26r in the sub-scanning direction can be expressed as follows.

[0040]

$$W = p \times n + \alpha$$

[0041]

In the formula,  $p$  is a single feed increment in the sub-scanning direction during a top- or lower-edge routine,  $n$  is the number of feed increments in the sub-scanning direction during a top- or lower-edge routine, and  $\alpha$  is an estimated feed error in the sub-scanning direction during a top- or lower-edge routine. The  $\alpha$ -value of the lower-edge routine (upstream slot 26f) should preferably be set to a level above that of the  $\alpha$ -value for an upper-edge routine (downstream slot 26r). Specifying the slot width of the platen according to this formula makes it possible to provide the slots with a width sufficient to adequately receive the ink droplets ejected from the nozzles during a top- or lower-edge routine.

[0042]

(2) Feeding in the Sub-scanning direction

(i) Upper-edge Routine of First Embodiment

Fig. 8 is a diagram depicting the manner in which raster lines are recorded by particular nozzles in an area near the upper edge (tip) of printing paper. For the sake of simplicity, the description will be limited to a single row of nozzles. It is assumed that a single row contains eight nozzles. During a main scan, each nozzle is responsible for recording a single raster line. As used herein, the term "raster line" refers to a row of pixels aligned in the main scanning direction. The term "pixel" refers to a single square of an imaginary grid formed on a print medium in order to define the positions at which dots are recorded by the deposition of ink droplets. In the case under consideration, the nozzles are spaced apart at intervals corresponding to three raster lines.

[0043]

In Fig. 8, a single vertical column of squares represents the print head 28. The numerals 1–8 in each square indicate nozzle numbers. In the present specification, "No." is attached to these numbers to indicate each nozzle. In Fig. 8, the print head 28, which is transported over time in relative fashion in the

sub-scanning direction, is shown moving in sequence from left to right. During the upper-edge routine, the single-dot incremental feeding in the sub-scanning direction is repeated seven times, as shown in Fig. 8. This upper-edge routine involves printing images in accordance with the first recording mode. As a unit of feed increment in the sub-scanning direction, the term "dot" designates a single-dot pitch corresponding to the printing resolution in the sub-scanning direction, and this dot is also equal to raster line pitch.

[0044]

The operation then proceeds to the intermediate routine and the 5-, 2-, 3-, and 6- dot feed increments are repeated in the order indicated. The intermediate routine involves printing images in accordance with the second recording mode. The system in which sub-scanning is performed by combining different feed increments in this manner is referred to as "non-constant feeding." Such feeding in the sub-scanning direction allows each raster line (with the exception of some raster lines) to be recorded by two nozzles. In other words, the present embodiment allows each raster line to be printed by two nozzles. In the example shown in Fig. 8, the fifth raster line from the top is recorded by nozzle Nos. 1 and 2. In the process, nozzle No. 2 may, for example, record pixels with even-numbered addresses, and nozzle No. 1 may record pixels with odd-numbered addresses. In addition, the ninth raster line from the top will be recorded by nozzle Nos. 2 and 3. The system in which the pixels within a single raster line are printed by a plurality of nozzles in distributed fashion in this manner will be referred to as "overlap printing." With such overlap printing, the dots of a single raster line are recorded by a plurality of nozzles passing over this raster line during a plurality of main scans for which the positions of printing paper in the sub-scanning direction are mutually different in relation to the print head.

[0045]

In Fig. 8, the four raster lines from the uppermost tier are such that the nozzle No. 1 makes only one pass per main scan during printing. The result is that pixels cannot be distributed between, and printed by, two nozzles for these raster lines. Consequently, it is assumed with reference to the present embodiment that these four raster lines cannot be used to record images. Specifically, it is assumed with reference to the present embodiment that only the fifth and greater raster lines, as counted from the upstream edge in the sub-scanning direction, can be considered as the raster lines on which the nozzles of the print head 28 can form dots in order to record images. The raster line area in which images can be recorded in this manner is referred to as a printable area. In addition, the raster line area in which image cannot be recorded is referred to as a nonprintable area. In Fig. 8, the numbers attached in order from top to the raster lines in which dots can be recorded by the nozzles of the print head 28 are indicated on the left side of the drawing. The same applies hereinbelow to the drawings illustrating the recording of dots during the upper-edge routine. In the drawings, the nozzles within bold boxes are used for recording dots on raster lines.

[0046]

In Fig. 8, three or more nozzles pass over the 13<sup>th</sup> to 15<sup>th</sup> raster lines from the top in the course of a main scan during printing. In the raster lines covered by three or more nozzles during printing, dots are recorded only by two of the nozzles involved. For these raster lines, the preferred practice is to record dots as much as possible with the nozzles that pass over the raster lines after the operation has entered the intermediate routine. With the intermediate routine, non-constant feeding is accomplished, and various combinations are created from the nozzles passing over mutually adjacent raster lines, making it possible to expect that the printing operation will yield better image quality than that yielded by the upper-edge routine, which is characterized by constant feeding in single-dot increments.



[0047]

In the present embodiment, images can be recorded without blank spaces up to the upper edge of the printing paper. As described above, the present embodiment is such that images can be recorded by selecting the fifth and greater raster lines (printable area), as counted from the upstream edge in the sub-scanning direction, from among the raster lines on which dots can be recorded by the nozzles of the print head 28. Consequently, images could theoretically be recorded very close to the upper edge of printing paper by starting dot recording after the printing paper is positioned relative to the print head 28 such that the fifth raster line (as counted from the upper edge) is disposed exactly at the position occupied by the upper edge of the printing paper. There are, however, cases in which the feed increment errors occur during feeding in the sub-scanning direction. There are also cases in which the direction in which ink droplets are ejected shifts away as a result of a manufacturing error or another factor related to the print head. The formation of blank spaces along the upper edge of the printing paper should preferably be prevented in cases in which the position at which the ink droplets are ejected on the printing paper is shifted for these reasons. It is thus assumed with reference to the present embodiment that the image data D used for printing are provided starting from the fifth raster line, which is counted from the upstream edge in the sub-scanning direction and is selected from the raster lines on which dots can be recorded by the nozzles of the print head 28, and that printing is started from a state in which the upper edge of the printing paper P assumes the position occupied by the seventh raster line, as counted from the upstream edge in the sub-scanning direction. Consequently, the prescribed position occupied by the upper edge of the printing paper in relation to each raster line during the start of printing coincides with the position occupied by the seventh raster line, as counted from the upstream edge in the sub-scanning direction (Fig. 8).

[0048]

Fig. 9 is a plan view depicting the relation between image data D and printing paper P. As described above, the present embodiment is such that image data D are provided up to the area outside the printing paper P beyond the upper edge Pf of the printing paper P. For the same reasons, the area facing the lower edge is also treated such that image data D are provided up to the area outside the printing paper P beyond the lower edge Pr of the printing paper P. The present embodiment is therefore such that the relation between the image data D and the size of the printing paper P, on the one hand, and the image data D and the arrangement of the printing paper P during printing, on the other hand, assumes the configuration shown in Fig. 9. In the present embodiment, two raster lines are selected for the width of the portion of image data D provided up to the area outside the printing paper P beyond the upper edge Pf of the printing paper P. Similarly, two raster lines are selected for the width of the portion of image data D provided up to the area outside the printing paper P beyond the lower edge Pr of the printing paper P. In the present specification, the terms "upper edge (portion)" and "lower edge (portion)" are used to designate the edges of the printing paper P corresponding to the top and bottom of the image data recorded on the printing paper P, and the terms "front edge (portion)" and "rear edge (portion)" are used to designate the edges of the printing paper P corresponding to the direction in which the printing paper P is advanced during sub-scanning in the printer 22. In the present specification, the term "upper edge (portion)" corresponds to the front edge (portion) of the printing paper P, and the term "lower edge (portion)" corresponds to the rear edge (portion).

[0049]

Fig. 10 is a side view depicting the relation between print head 28 and printing paper P at the start of printing. It is assumed herein that the platen 26 covers the range R26 extending from a rearward position corresponding to two raster lines (as counted from nozzle No. 2 of the print head 28) to a forward

position corresponding to two raster lines (as counted from nozzle No. 7). Consequently, the ink droplets from nozzle Nos. 1, 2, 7, and 8 are prevented from depositing on the platen 26 even when the ink droplets  $I_p$  are ejected from the nozzles in the absence of printing paper.

5 [0050]

In Fig. 7, the nozzles  $N_r$  in the hatched portion of the print head 28 correspond to the area in which nozzle Nos. 1 and 2 are disposed. A downstream slot 26r is disposed underneath the area over which these nozzles pass during a main scan, and printing is started when the upper edge  $P_f$  of the printing paper  $P$  reaches the position shown by the dashed line over the downstream slot 26r.

[0051]

As described above, the upper edge  $P_f$  of the printing paper  $P$  reaches the position of the seventh raster line (as counted from the upstream edge in the sub-scanning direction), which is one of the raster lines on which dots are recorded by the nozzles of the print head 28. Specifically, it follows from Fig. 10 that the upper edge of the printing paper  $P$  reaches a rearward position corresponding to six raster lines, as counted from nozzle No. 1. The broken lines in Fig. 10 indicate the prescribed positions of raster lines based on image data. If it is assumed that printing starts at this position, then the raster line belonging to the uppermost tier of the printable area (fifth raster line from the top in Fig. 8) is supposed to be recorded by nozzle No. 2, but the printing paper  $P$  has not yet reached the area underneath nozzle No. 2. The result is that accurate feeding of the printing paper  $P$  by the upstream paper feed rollers 25a and 25b will allow the ink droplets  $I_p$  ejected by nozzle No. 2 to descend directly into the downstream slot 26r. In addition, the raster line belonging to the uppermost tier of the printable area will also be recorded by nozzle No. 1 following four single-dot feed increments, as shown in Fig. 8. Similarly, the printing paper  $P$  has not yet reached the area underneath nozzle No. 1 by the

time four single-dot feed increments are completed. The result is that the ink droplets  $Ip$  ejected from nozzle No. 1 at this time descend directly into the downstream slot 26r. The same applies to recording the second raster line from the top of the printable area (sixth raster line from the top in Fig. 8).

5 [0052]

There are also cases in which the upper edge of the printing paper  $P$  reaches the position occupied by the second raster line from the top of the printable area or by the raster line disposed in the uppermost tier of the printable area if the feed increment of the printing paper  $P$  exceeds the designed  
10 increment for any reason. The present embodiment is configured such that nozzle Nos. 1 and 2 are still capable of ejecting ink droplets  $Ip$  to cover the aforementioned raster lines in such cases, making it possible to record images along the upper edge of the printing paper  $P$  and to prevent blank spaces from forming. Specifically, blank spaces can be prevented from forming along the  
15 upper edge of the printing paper  $P$  when the feed increment of the printing paper  $P$  exceeds the designed increment but the excessive feed increment is still no more than two raster lines, as shown by the dashed line in Fig. 10.

[0053]

Another possibility is that the feed increment of the printing paper  $P$  falls  
20 short of the designed increment for any reason. In such cases the printing paper fails to arrive at the designated position, and the ink droplets  $Ip$  end up depositing on the underlying structure. In the present embodiment, the two raster lines along the intended upper-edge position of the paper sheet are recorded by nozzle Nos. 1 and 2, as shown in Fig. 8. A downstream slot 26r is  
25 disposed underneath these nozzles, so the ink droplets  $Ip$  descend into the downstream slot 26r and are absorbed by an absorbent member 27r if they fail to deposit on the printing paper  $P$ . It is thus possible to prevent situations in which the ink droplets  $Ip$  deposit on the upper surface of the platen 26 and subsequently soil the printing paper. Specifically, adopting the present

embodiment makes it possible to prevent situations in which the ink droplets  $Ip$  deposit on the upper surface of the platen 26 and subsequently soil the printing paper P when the upper edge Pf of the printing paper P moves past the intended position of the upper edge during the start of printing but the deviation of the paper from the intended position of the upper edge is still no more than two raster lines.

[0054]

The printing paper P should be held and fed in the sub-scanning direction by two groups of rollers composed of the upstream paper feed rollers 25a and 25b and the downstream paper feed rollers 25c and 25d. The reason is that this arrangement allows paper to be fed in the sub-scanning direction with higher accuracy than when the sheet is held and fed in the sub-scanning direction by a single roller. However, the printing paper P is held and fed in the sub-scanning direction solely by the upstream paper feed rollers 25a and 25b when images are printed along the upper edge Pf of the printing paper. In the present embodiment, printing is started when the seventh raster line, as counted from the upstream edge in the sub-scanning direction and selected from raster lines on which dots can be recorded by the nozzles of the print head 28, reaches the position occupied by the upper edge Pf of the printing paper (see Figs. 8 and 10). Consequently, images are printed as the sheet is fed in the sub-scanning direction solely with the upstream paper feed rollers 25a and 25b from this position onward until the upper edge Pf of the printing paper is picked up by the downstream paper feed rollers 25c and 25d, that is, in the period during which the printing paper travels the distance L31, as shown in Fig. 10. In the present embodiment, the printing operation yields better image quality because the sheet is fed in the sub-scanning direction solely by the upstream paper feed rollers 25a and 25b, and the printing operation is completed in a comparatively short time. These effects are not limited to the above-described arrangement and extend to situations in which the area near the upper edge Pf of the printing

paper is printed with nozzles located in the vicinity of the edge on the downstream side in the sub-scanning direction. This arrangement is particularly effective in cases in which the upstream drive units (upstream paper feed rollers 25a and 25b) for sub-scanning have comparatively low feed accuracy.

[0055]

The printing paper P is supported at two locations on the platen 26 and the upstream paper feed rollers 25a and 25b when images are printed on the area occupied by the upper edge. For this reason, the upper-edge portion of the printing paper P has comparatively high resistance to downward bending when disposed above the downstream slot 26r. It is therefore less likely that the quality of printing in the upper-edge portion will be adversely affected by the bending of the printing paper.

[0056]

#### (ii) Upper-edge Feeding According to Comparative Example

Fig. 11 is a side view depicting the relation between print head 28 and printing paper P at the start of printing according to a comparative example. It can be seen in Fig. 11 that the ink droplets not deposited on the printing paper P are prevented from depositing on the upper surface of the platen 26 when images are printed in the upper-edge portion of the printing paper P over the upstream slot 26f. In this comparative example, however, printing is started in the upper-edge portion of the printing paper, so the distance L32 (see Fig. 11) traveled by the printing paper until the upper edge of the printing paper is held by the downstream paper feed rollers 25c and 25d is greater than the distance (L31 in Fig. 8) traveled according to the embodiment. In other words, the sheet is fed in the sub-scanning direction solely by the upstream paper feed rollers 25a and 25b, and the printing period is comparatively long. The print quality is therefore lower than in the embodiment.

[0057]

The printing paper P is held solely by the upstream paper feed rollers 25a and 25b when images are printed in the upper-edge portion. The upper-edge portion of the printing paper P will therefore likely to bend downward over the upstream slot 26f. There is, therefore, a comparatively high possibility that the print quality will decrease when images are printed in the upper-edge portion.

[0058]

(iii) Lower-edge Routine of First Embodiment

Fig. 12 is a diagram depicting the manner in which raster lines are recorded by particular nozzles during the lower-edge routine. Fig. 12 depicts the results obtained from the moment an  $(n + 1)$ -th feed increment is completed in the sub-scanning direction until the moment the final  $(n + 17)$ -th feed increment is completed in the sub-scanning direction. In the present embodiment, the lower-edge routine entails performing the last nine (that is, from  $(n + 9)$ -th to  $(n + 17)$ -th) single-dot feed increments in the sub-scanning direction after 5-, 2-, 3- and 6-dot feed increment are repeatedly performed in sequence in the sub-scanning direction up to the  $(n + 8)$ -th cycle of the intermediate routine, as shown in Fig. 12. As a result, each of the raster lines (with the exception of some raster lines) aligned in the main scanning direction is recorded by two nozzles. In Fig. 12, the numbers attached in order from the bottom to the raster lines in which dots can be recorded by the nozzles of the print head 28 are indicated on the right side of the drawing. The rest is the same as in the drawings illustrating the recording of dots by the lower-edge routine.

[0059]

In Fig. 12, the four raster lines from the lowermost tier are such that nozzle No. 8 makes only one pass during printing. The fifth and greater raster lines above the lowermost tier are recorded by two or more nozzles. Consequently, the printable area of the portion occupied by the lower edge of the printing paper extends to the fifth and greater raster lines from the lowermost tier.

[0060]

In Fig. 12, three or more nozzles pass over the ninth and tenth raster lines from the bottom in the course of a main scan during printing. For the raster lines covered by three or more nozzles during printing, the preferred practice is to record dots as much as possible with the nozzles that pass over the raster lines during an intermediate routine. The printing operation can be expected to yield better image quality than when a lower-edge routine is performed in single-dot constant feed increments.

[0061]

In the present embodiment, images can be recorded without blank spaces up to the lower edge in the same manner for the upper edge. As described above, the present embodiment is such that images can be recorded by selecting the fifth and greater raster lines (printable area), as counted from the downstream edge in the sub-scanning direction, from among the raster lines that can be used to record dots by the nozzles of the print head 28. It is assumed, however, that images are recorded on the printing paper starting from the seventh raster line (as counted from the downstream edge in the sub-scanning direction) because of considerations related, among other things, to the feed increment errors that occur during feeding in the sub-scanning direction. Specifically, ink droplets  $I_p$  are ejected over the fifth and sixth raster lines, and the final main scan of the printing operation is performed in a state in which the lower edge of the printing paper is at a position corresponding to the seventh raster line, as counted from the upstream edge in the sub-scanning direction. Consequently, the intended position of the lower edge of the printing paper in relation to each raster line during the end of printing coincides with the position occupied by the seventh raster line, as counted from the downstream edge in the sub-scanning direction (Fig. 12).

[0062]



Fig. 13 is a plan view depicting the relation between the printing paper P and upstream slot 26f during printing in the lower-edge portion Pr of the printing paper P. In Fig. 13, the nozzles Nf in the hatched area of the print head 28 correspond to the area in which nozzle Nos. 7 and 8 are located. An upstream slot 26f is disposed underneath the area over which these nozzles pass during a main scan, and printing is completed when the lower edge Pr of the printing paper P reaches the position shown by the dashed line above the upstream slot 26f.

[0063]

Fig. 14 is a side view depicting the relation between the printing paper P and print head 28 during printing in the lower-edge portion Pr of the printing paper P. When images are printed in the lower-edge portion Pr of the printing paper P, the lower edge Pr of the printing paper P is disposed at the position occupied by the seventh raster line (as counted from the downstream edge in the sub-scanning direction), which is a raster line on which dots can be recorded by the nozzles of the print head 28, as described above (see Fig. 12). In other words, the lower edge of the printing paper P is disposed at a position six raster lines in front of nozzle No. 8. The ink droplets Ip ejected from the nozzle Nos. 7 and 8 will therefore directly descend into the upstream slot 26f if it is assumed that dots are recorded in the lowermost tier of the printable area and on the second raster line from the lowermost tier (sixth and fifth raster lines from bottom in Fig. 12).

[0064]

If the feed increment of the printing paper P falls below the designed increment for any reason, nozzle Nos. 7 and 8 move beyond the lower edge Pr of the printing paper P and discharge ink droplets Ip for the designated raster lines (fifth and sixth raster lines from bottom in Fig. 12), making it possible to record images along the lower edge Pr of the printing paper P without leaving any blank spaces. Specifically, blank spaces can be prevented from forming

along the lower edge of the printing paper P when the deficit of the feed increment is no more than two raster lines, as shown by the dashed line in Fig. 14.

[0065]

5       The two raster lines (seventh and eighth raster lines from bottom in Fig. 12) along the intended upper-edge position of the paper sheet are recorded by nozzle Nos. 7 and 8. It is therefore possible to prevent situations in which the ejected ink droplets  $lp$  fall into the upstream slot 26f and deposit in the area occupied by the upper surface of the platen 26 when the feed increment of the printing paper P falls below the designed increment for any reason.

[0066]

15       In the present embodiment, printing is completed when the seventh raster line, as counted from the downstream edge in the sub-scanning direction and selected from raster lines on which dots can be recorded by the nozzles of the print head 28, reaches the position occupied by the lower edge  $Pr$  of the printing paper (that is, a position two raster lines in front of nozzle No. 7 in Fig. 14) (see also Fig. 12). Consequently, images are printed as the sheet is fed in the sub-scanning direction solely with the downstream paper feed rollers 25c and 25d in the period during which the printing paper P travels the distance  $L41$ , which is the distance between the point at which the lower edge  $Pr$  of the printing paper P leaves the upstream paper feed rollers 25a and 25b, and the point shown in Fig. 14. In the present embodiment, the printing operation yields better image quality because the sheet is fed in the sub-scanning direction solely by the downstream paper feed rollers 25c and 25d, and the printing operation is completed in a comparatively short time. In particular, the downstream paper feed roller 25d is a gear-type roller, and the combined downstream paper feed rollers 25c and 25d can feed the sheet less accurately than can the upstream paper feed rollers 25a and 25b. For this reason, adopting an arrangement in which the sheet is fed in the sub-scanning direction solely by the downstream

paper feed rollers 25c and 25d and in which the printing operation is completed in a comparatively short time is highly effective for enhancing the quality of the final print. These effects are not limited to the above-described arrangement and extend to situations in which the area near the lower edge Pr of the printing paper is printed with nozzles located in the vicinity of the edge on the upstream side in the sub-scanning direction. This arrangement is particularly effective in cases in which the downstream drive units (downstream paper feed rollers 25c and 25d) for sub-scanning have comparatively low feed accuracy.

[0067]

The printing paper P is supported at two locations on the platen 26 and the downstream paper feed rollers 25c and 25d when images are printed on the area occupied by the lower edge. For this reason, the lower-edge portion of the printing paper P has comparatively high resistance to downward bending when disposed above the upstream slot 26f. It is therefore less likely that the quality of printing in the upper-edge portion will be adversely affected by the bending of the printing paper.

[0068]

#### (iv) Lower-edge Feeding in Comparative Example

Fig. 15 is a side view depicting the relation between the print head 28 and printing paper P when the lower edge Pr of the printing paper P is printed according to a comparative example. It can be seen in Fig. 15 that the ink droplets not deposited on the printing paper P are prevented from depositing on the upper surface of the platen 26 when images are printed in the lower-edge portion of the printing paper P above the downstream slot 26r. In this comparative example, however, the distance L42 traveled by the printing paper until the lower edge thereof is held by the upstream paper feed rollers 25a and 25b is greater than the distance (L41 in Fig. 14) traveled according to the embodiment, as shown in Fig. 15. In other words, the sheet is fed in the sub-scanning direction solely by the downstream paper feed rollers 25c and 25d

(which have comparatively low feed accuracy), and the printing period is comparatively long. The print quality is therefore lower than in the embodiment.

[0069]

The printing paper P is held solely by the downstream paper feed rollers 25c and 25d when images are printed in the lower-edge portion. The lower-edge portion of the printing paper P will therefore likely to bend downward over the downstream slot 26r. There is, therefore, a comparatively high possibility that the print quality will decrease when images are printed in the lower-edge portion.

[0070]

#### C. Second Embodiment

Fig. 16 is a side view depicting the relation of a print head 28a with an upstream slot 26fa and a downstream slot 26ra according to a second embodiment. A case will now be described in which upper- and lower-edge routines are performed by a printing device in which a single nozzle row contains 11 nozzles. In the printing device used herein, the downstream slot 26ra is provided at a position opposite nozzle Nos. 1–3 in the sub-scanning direction. The upstream slot 26fa is provided at a position opposite nozzle Nos. 9–11. The rest of the structure is the same as that of the printing device described above. Another feature of the second embodiment is that the overlap printing is dispensed with. In other words, each raster line is recorded by a single nozzle in the course of a main scan.

[0071]

##### (1) Upper-edge Routine of Second Embodiment

Figs. 17 and 18 are diagrams depicting the manner in which raster lines are recorded by particular nozzles in accordance with the upper-edge routine of the second embodiment. Figs. 17 and 18 depict two separate levels (upper and lower) of the process in which the head records the raster lines. The lower

part of Fig. 17 is connected to the upper part of Fig. 18. The 38<sup>th</sup> to 42<sup>nd</sup> raster lines from the top are shown in overlapped form in Figs. 17 and 18.

[0072]

During the upper-edge routine of the second embodiment, 3-dot incremental feeding in the sub-scanning direction is repeated 11 times, as shown in Fig. 17. This upper-edge routine involves printing images in accordance with the first recording mode. The upper-edge routine is performed without the use of nozzles other than nozzle Nos. 1–3 of the print head 28a. In the drawings, the nozzles within bold boxes are used for recording dots on raster lines.

[0073]

Instead of an intermediate routine being performed immediately thereafter, a transitional routine is carried out prior to the intermediate routine. Similar to the upper-edge routine, the transitional routine involves repeating 3-dot feed increments four times in the sub-scanning direction. All the nozzles (Nos. 1–11) are used in the transitional routine. The operation then proceeds to the intermediate routine, and constant 11-dot feed increments are then repeated, as shown in Fig. 18. This intermediate routine involves printing images in accordance with the second recording mode.

[0074]

In Fig. 17, none of the nozzles pass over the second, third, or six raster line (as counted from the uppermost tier) during main-scan printing. It is therefore impossible to print pixels by connecting together adjacent raster lines selected from the raster lines extending from the uppermost tier to the sixth raster line. In the present embodiment, these six raster lines constitute a nonprintable area. For a raster line covered by two or more nozzles, such as the 13<sup>th</sup> to 16<sup>th</sup> raster lines from the top, it is assumed that dots are formed exclusively by the last nozzle passing over the raster line.

[0075]

In the second embodiment, images can be recorded by selecting the seventh and greater raster lines (printable area), as counted from the upstream edge in the sub-scanning direction, from among the raster lines on which dots can be recorded by the nozzles of the print head 28a. The image data D used for printing are provided starting from the seventh raster line, as counted from the upstream edge in the sub-scanning direction. For the same reasons as those described with reference to the first embodiment, printing is started when the upper edge of the printing paper P reaches the position occupied by the 23<sup>rd</sup> raster line rather than the seventh raster line, as counted from the upstream edge in the sub-scanning direction. Specifically, the intended position of the upper edge of the printing paper P in relation to each raster line at the start of printing coincides with the position occupied by the 23<sup>rd</sup> raster line, as counted from the upstream edge in the sub-scanning direction (Fig. 17). Consequently, the second embodiment entails providing image data D for 16 raster lines, beyond the intended position of the upper edge of the printing paper P. For this reason, images can still be formed without blank spaces up to the upper edge of the printing paper P when an error affecting the feeding of the printing paper P has occurred and the printing paper P is fed in an excessive manner, provided the error is within 16 raster lines.

[0076]

Another feature of the second embodiment is that nozzle Nos. 1–3 are the only nozzles involved in the recording of the 20 raster lines counted from the position occupied by the upper edge and the 16 preset raster lines extending beyond the intended position of the upper edge of the printing paper P. A downstream slot 26ra is disposed underneath nozzle Nos. 1–3. Ink droplets can therefore be prevented from depositing on a platen 26a when these droplets are ejected onto the 16 preset raster lines beyond the intended position of the upper edge of the printing paper P (that is, onto the area beyond the printing paper). It is also possible to prevent the ink droplets from depositing on the

platen 26a when these droplets are ejected onto the raster lines in an area outside the upper-edge portion of the printing paper P in a state in which a feed error affecting the printing paper P has occurred and the printing paper P fails to arrive at the intended position, provided the feed error is within 20 raster lines.

5 [0077]

## (2) Lower-edge Routine of Second Embodiment

Figs. 19 and 20 are diagrams depicting the manner in which raster lines are recorded by particular nozzles in accordance with the lower-edge routine of the second embodiment. The case shown in Fig. 19 involves  $(n + 1)$ -th and greater feed increments in the sub-scanning direction. Figs. 19 and 20 depict two separate levels (upper and lower) of the process in which the head records the raster lines. The lower part of Fig. 19 is connected to the upper part of Fig. 20. The 45<sup>th</sup> to 40<sup>th</sup> raster lines from the bottom are shown in overlapped form in Figs. 19 and 20.

15 [0078]

In the present embodiment, 3-dot feeding is repeated four times in accordance with a transitional routine after 11-dot constant feeding has been repeated in the sub-scanning direction from the  $(n + 1)$ -th cycle to the  $(n + 3)$ -th cycle in accordance with an intermediate routine, as shown in Figs. 19 and 20. Three-dot feeding is then performed using solely nozzle Nos. 9–11 in accordance with a lower-edge routine.

[0079]

In the second embodiment, images can be recorded by selecting the seventh and greater raster lines (printable area, counted from the bottom) from the raster lines on which dots can be recorded by the nozzles of the print head 28, as shown in Fig. 20. In the second embodiment, however, images are recorded using the eighth and greater raster lines from the bottom. In other words, the eighth and greater raster lines from the bottom in Fig. 20 constitute a printing area, and image data are specified for these raster lines.

[0080]

In Fig. 20, a raster line such as the 13<sup>th</sup> or 16<sup>th</sup> raster line from the bottom is covered by two or more nozzles during a main print scan. For a raster line covered by two or more nozzles during printing, dots are recorded by the last nozzle passing over the raster line.

[0081]

In the second embodiment, images can be recorded by selecting the eighth and greater raster lines, as counted from the downstream edge in the sub-scanning direction, from among the raster lines on which dots can be recorded by the nozzles of the print head 28a. The image data D used for printing are provided starting from the eighth raster line. For the same reasons as those described with reference to the first embodiment, printing is completed when the lower edge of the printing paper P reaches the position occupied by the 38<sup>th</sup> raster line rather than the eighth raster line, as counted from the downstream edge in the sub-scanning direction. Specifically, the intended position of the lower edge of the printing paper P in relation to each raster line at the end of printing coincides with the position occupied by the 38<sup>th</sup> raster line, as counted from the downstream edge in the sub-scanning direction (Fig. 20). Consequently, the second embodiment entails providing image data D equivalent to 30 raster lines, beyond the intended position of the lower edge of the printing paper P. For this reason, images can still be formed without blank spaces up to the lower edge when an error affecting the feeding of the printing paper P has occurred and the printing paper P fails to arrive at the intended position, provided the error is within 30 raster lines.

[0082]

Another feature of the second embodiment is that nozzle Nos. 9–11 are the only nozzles involved in the recording of the 20 upstream raster lines counted from the position occupied by the lower edge and the 30 preset raster lines extending beyond the intended position of the lower edge of the printing



paper P. An upstream slot 26fa is disposed underneath nozzle Nos. 9–11. Ink droplets can therefore be prevented from depositing on a platen 26a when these droplets are ejected onto the preset raster lines beyond the intended position of the lower edge of the printing paper P (that is, onto the area beyond  
5 the printing paper). It is also possible to prevent the ink droplets from depositing on the platen 26a when these droplets are ejected onto the raster lines in an area outside the lower-edge portion of the printing paper P in a state in which a feed error affecting the printing paper P has occurred and the printing paper P is fed in an excessive manner, provided the feed error is within 20 raster  
10 lines.

[0083]

The printing paper P travels a longer distance when images are recorded in the area along the lower edge of the printing paper P than when images are recorded in the area along the upper edge of the printing paper P. It is highly  
15 likely, therefore, that when images are recorded the area along the lower edge of the printing paper P is recorded, the positional error of the printing paper P will be greater than when images are recorded in the area along the upper edge of the printing paper P. In addition, the downstream paper feed roller 25d is a gear-type roller, and the combined downstream paper feed rollers 25c and 25d  
20 can feed the sheet with less accuracy than when the upstream paper feed rollers 25a and 25b are involved. This is another factor that increases the likelihood that the error created during the recording of the area along the lower edge will be greater than the positional error of the printing paper P created during the recording of the area along the upper edge. Consequently, the number of  
25 raster lines recorded solely by the nozzles (Nos. 9–11) above the upstream slot 26fa in the lower-edge portion of the printing paper P should preferably be set above the number of raster lines recorded solely by the nozzles (Nos. 1–3) above the downstream slot 26ra in the upper-edge portion of the printing paper P in the manner adopted in the second embodiment. For image data D, the

number of raster lines selected for the area beyond the lower edge of the printing paper P should preferably be set above the number of raster lines selected for the area beyond the upper edge of the printing paper P.

[0084]

#### 5 D. Third Embodiment

Fig. 21 is a side view depicting the relation of a print head 28b with an upstream slot 26fb and a downstream slot 26rb according to a third embodiment. A case will now be described in which upper- and lower-edge routines are performed by a printing device configured such that a single nozzle row contains  
10 48 nozzles. In the printing device used herein, the downstream slot 26rb is provided at a position opposite nozzle Nos. 1–12 in the sub-scanning direction. The upstream slot 26fb is provided at a position opposite nozzle Nos. 37–48. The rest of the structure is the same as that of the printing device described above.

15 [0085]

Fig. 22 is a diagram depicting the arrangement of ink-jet nozzles Nz in the ink-injecting heads 61b–66b pertaining to the third embodiment. In the third embodiment, the nozzles and the raster lines have the same pitch. Consequently, the print head 28b can record dots on adjacent raster lines by a  
20 single main scan. In Fig. 22, the area on the platen 26b opposite the downstream slot 26rb is labeled Rr, and the area opposite the upstream slot 26fb is labeled Rf. Area Rr accommodates nozzle Nos. 1–12, and area Rf accommodates nozzle Nos. 37–48. In the third embodiment, overlap printing is performed using the print head 28b.

25 [0086]

##### (1) Upper-edge Routine of Third Embodiment

Figs. 23 and 24 are diagrams depicting the manner in which raster lines are recorded by particular nozzles in accordance with the upper-edge routine of the third embodiment. The lower part of Fig. 23 is connected to the upper part

of Fig. 24. The 66<sup>th</sup> to 74<sup>th</sup> raster lines from the top are shown in overlapped form.

[0087]

During the upper-edge routine of the third embodiment, 6-dot incremental feeding in the sub-scanning direction is repeated ten times, as shown in Fig. 23. This upper-edge routine involves printing images in accordance with the first recording mode. The upper-edge routine is performed without the use of nozzles other than nozzle Nos. 1–12 of the print head 28b. In the drawings, the nozzles within bold boxes are used for recording dots on raster lines. The nozzles used for the upper-edge routine are labeled "nozzle group N1" in Fig. 22.

[0088]

A transitional routine is subsequently carried out. The transitional routine is similar to the upper-edge routine in that feeding in 6-dot increments is carried out twice in the sub-scanning direction. The transitional routine is also similar to the upper-edge routine in that the final feed is followed by an operation in which dots are recorded by nozzle Nos. 1–12. Nozzle Nos. 1–30 are used after the second feed. The operation then proceeds to the intermediate routine, and 24-dot constant feeds are repeated, as shown in Fig. 24. All the nozzles (Nos. 1–48) are used in the intermediate routine. The intermediate routine involves printing images in accordance with the second recording mode. The nozzles used in the transitional routine after the second feed are labeled "nozzle group N2" in Fig. 22. The nozzles used in the intermediate routine are labeled "nozzle group N3" in Fig. 22.

[0089]

In Fig. 23, overlap printing is dispensed with because the nozzles pass only once over the group of raster lines extending from the uppermost tier to the sixth raster line during a main print scan. In the present embodiment, these six raster lines constitute a nonprintable area. Of the raster lines covered by two or

more nozzles, such as the 13<sup>th</sup> and greater raster lines from the top, dots can be recorded only by the last nozzles passing over the raster lines, and by the nozzles passing over the raster lines immediately before the last nozzles.

[0090]

5 In the third embodiment, the image data D used for printing are specified based on the seventh raster line (as counted from the upstream edge in the sub-scanning direction), which constitutes the upper edge of the printable area. For the same reasons as in the first embodiment, printing is started after the upper edge of the printing paper P reaches the position occupied by the 37<sup>th</sup>  
10 raster line, as counted from the upstream edge in the sub-scanning direction. This position is labeled in Fig. 23 as the intended position of the upper edge of the printing paper P. In other words, the third embodiment entails providing image data D for 36 raster lines, beyond the intended position of the upper edge of the printing paper P. For this reason, images can still be formed without  
15 blank spaces up to the upper edge of the printing paper P when an error affecting the feeding of the printing paper P has occurred and the printing paper P is fed in an excessive manner, provided the error is within 36 raster lines.

[0091]

Another feature of the third embodiment is that nozzle Nos. 1–12 above  
20 the downstream slot 26rb are the only nozzles involved in the recording of the 42 raster lines counted from the position occupied by the upper edge and the 36 preset raster lines extending beyond the intended position of the upper edge of the printing paper P. Ink droplets can therefore be prevented from depositing on the platen 26a when these droplets are ejected onto the 36 preset raster lines  
25 beyond the intended position of the upper edge of the printing paper P (that is, onto the area beyond the printing paper). It is also possible to prevent the ink droplets from depositing on the platen 26b when these droplets are ejected onto the raster lines in an area outside the upper-edge portion of the printing paper P in a state in which a feed error affecting the printing paper P has occurred and

the printing paper P has failed to arrive at the intended position, provided the feed error is within 42 raster lines.

[0092]

## (2) Lower-edge Routine of Third Embodiment

5 Figs. 25 and 26 are diagrams depicting the manner in which raster lines are recorded by particular nozzles in accordance with the lower-edge routine of the third embodiment. The lower part of Fig. 25 is connected to the upper part of Fig. 26.

[0093]

10 In the present embodiment, 24-dot constant feeds are repeated in accordance with the intermediate routine, and a single 6-dot feed is performed in accordance with the transitional routine, as shown in Fig. 25. Nozzle Nos. 19–48 are used following this feed. A 6-dot feed is then made using solely nozzle Nos. 37–48 in accordance with the lower-edge routine. The nozzles  
15 used following the feed performed in accordance with the transitional routine are those labeled "nozzle group N4" in Fig. 22. The nozzles used for the lower-edge routine are those labeled "nozzle group N5" in Fig. 22.

[0094]

In the third embodiment, images may be recorded by selecting the seventh  
20 and greater raster lines (printable area, counted from the bottom) from the raster lines on which dots can be recorded by the nozzles of the print head 28, as shown in Fig. 26. In the third embodiment, however, images are recorded using the ninth and greater raster lines from the bottom. In other words, the ninth and greater raster lines from the bottom in Fig. 26 constitute a printing area,  
25 and image data are specified for these raster lines.

[0095]

In Fig. 26, the 13<sup>th</sup> and greater raster lines from the bottom are covered by two or more nozzles during a main print scan. For a raster line covered by two or more nozzles during printing, dots are recorded by the last nozzle passing

over the raster lines, and by the subsequent nozzles passing over the raster lines.

[0096]

In the third embodiment, the image data D used for printing are specified up to the ninth raster line from the bottom. For the same reasons as in the first embodiment, printing is completed after the lower edge of the printing paper P reaches the position occupied by the 49<sup>th</sup> raster line rather than the position occupied by the ninth raster line, as counted from the downstream edge in the sub-scanning direction. Fig. 26 depicts the intended position of the lower edge of the printing paper P in relation to the raster lines at the end of printing. Consequently, the third embodiment entails providing image data D for 40 raster lines, beyond the intended position of the lower edge of the printing paper P. For this reason, images can still be formed without blank spaces up to the lower edge when an error affecting the feeding of the printing paper P has occurred and the printing paper P fails to arrive at the intended position, provided the error is within 40 raster lines.

[0097]

Another feature of the third embodiment is that nozzle Nos. 37–48 above the upstream slot 26fb are the only nozzles involved in the recording of the 36 raster lines counted from the position occupied by the lower edge and the 40 preset raster lines extending beyond the intended position of the lower edge of the printing paper P. Ink droplets can therefore be prevented from depositing on the platen 26b when these droplets are ejected onto the preset raster lines beyond the intended position of the lower edge of the printing paper P (that is, onto the area beyond the printing paper). It is also possible to prevent the ink droplets from depositing on the platen 26a when these droplets are ejected onto the raster lines in an area outside the lower-edge portion of the printing paper P in a state in which a feed error affecting the printing paper P has occurred and

the printing paper P is fed in an excessive manner, provided the feed error is within 36 raster lines.

[0098]

Yet another feature of the third embodiment is that the number of raster  
5 lines recorded solely by the nozzles (Nos. 37–48) disposed above the upstream slot 26fb in the lower-edge portion of the printing paper P is set above the number of raster lines recorded solely by the nozzles (Nos. 1–12) disposed above the downstream slot 26rb in the upper-edge portion of the printing paper P. For image data D, the number of raster lines selected for the area beyond  
10 the lower edge of the printing paper P is set above the number of raster lines selected for the area beyond the upper edge of the printing paper P.

[0099]

#### E. Embodiment With Lateral Slot

The above description was given with reference to an embodiment in  
15 which a printer 22 comprising an upstream slot 26f and a downstream slot 26r in a platen 26 was used to print images on the basis of image data D (see Fig. 9) provided for an area beyond the lower and upper edges of a printing paper P, as shown in Fig. 7. Following is a description of an embodiment in which a printer 22n whose platen is fitted with a left slot 26na and a right slot 26nb in addition to  
20 the upstream slot 26f and downstream slot 26r is used to print images on the basis of image data Dn provided for an area beyond the upper, lower, left, and right edges of a printing paper P.

[0100]

Fig. 27 is a plan view depicting the relation between image data Dn and  
25 printing paper P. In Fig. 27, the image data Dn are provided for the area outside the printing paper P not only beyond the upper edge Pf and lower edge Pr edges of the printing paper P but also along the left edge Pa and right edge Pb thereof. Fig. 27 depicts the resulting relation between the image data Dn and the size of the printing paper P, on the one hand, and the image data Dn

and the arrangement of the printing paper P during printing, on the other hand, in accordance with the present embodiment. The width of an image (width of expanded area) that can be recorded with the image data Dn is such that the image extends beyond the left and right edges of the printing paper P but fits  
5 between the side walls of the exterior portions of the left slot 26na and right slot 26nb. Because the terms "left" and "right" for the left edge Pa and right edge Pb are selected to match the terms "left" and "right" for the printer 22, the actual left and right sides of the printing paper P are the reverse of those designated by the terms "left edge Pa" and "right edge Pb."

10 [0101]

Fig. 28 is a plan view depicting the periphery of a platen 26n for a printer 22n. The printer 22n is equipped with guides 29a and 29b for keeping the printing paper P at a specified position in the main scanning direction during the sub-scanning of the printing paper P. Similar to the platen 26 in Fig. 7, the  
15 platen 26n is provided with an upstream slot 26f and a downstream slot 26r. The platen 26n further comprises a left slot 26na and a right slot 26nb, which extend in the sub-scanning direction to connect the two corresponding ends of the upstream slot 26f and downstream slot 26r. The left slot 26na and right slot 26nb are provided within a range (in the sub-scanning direction) greater than the  
20 range within which ink droplets can be deposited by the nozzles of the print head. The left slot 26na and right slot 26nb are arranged such that the distance between the center lines thereof (in the main scanning direction) is equal to the width of the printing paper P in the main scanning direction. Other structural elements are the same as those of the above-described printer 22.

25 [0102]

The left slot 26na and right slot 26nb should be configured such that one of the side-edge portions (side-edge portion Pa) of the printing paper P in the main scanning direction is disposed above the opening of the left slot 26na, and the other side-edge portion (side-edge portion Pb) is disposed above the opening of



the right slot 26nb when the printing paper P is brought to a specified main-scan position by the guides 29a and 29b. An arrangement in which the side-edge portions of the printing paper P are disposed at a point located inward or outward from the center lines of the left slot 26na and right slot 26nb can therefore be adopted for the left slot 26na and right slot 26nb in addition to an embodiment in which the side-edge portions of the printing paper P are disposed along the center lines of the left slot 26na and right slot 26nb when the printing paper is brought into a specified position in this manner.

[0103]

The upstream slot 26f, downstream slot 26r, left slot 26na, and right slot 26nb are connected to each other, forming a quadrilateral slot. An absorbent member 27 for receiving and absorbing ink droplets Ip is disposed on the bottom thereof.

[0104]

The printing paper P passes above the openings of the upstream slot 26f and downstream slot 26r when fed in the sub-scanning direction by the upstream paper feed rollers 25a and 25b and the downstream paper feed rollers 25c and 25d. The printing paper P is positioned on the platen 26n by the guides 29a and 29b in the main scanning direction such that the left edge Pa is disposed above the left slot 26na, and the right edge Pb is disposed above the right slot 26nb. The two side edges of the printing paper P are thereby fed while kept at positions above the openings of the left slot 26na and right slot 26nb, respectively, during sub-scanning.

[0105]

In the embodiment shown in Fig. 28, the feeding methods of the above-described first through third embodiments can be adopted for the secondary-scan feeding of the upper- and lower-edge routines in accordance with the positional relation between the platen 26n and the nozzles of the nozzle

row. A description is therefore given below concerning the printing of images in the side-edge portions Pa and Pb of the printing paper P.

[0106]

Fig. 29 is a diagram depicting the manner in which images are printed in the left and right side-edge portions of the printing paper P. The embodiment shown in Fig. 28 includes upper- and lower-edge routines, and images can be printed without blank spaces in the left and right edge portions of the printing paper P throughout the entire operation in which images are printed on the printing paper P. In the process, the print head 28 is transported in the main scanning direction until all the nozzles have moved beyond one of the edges of the printing paper P and reached a position outside the printing paper P, and until all the nozzles have moved beyond the other edge of the printing paper P and reached a position outside the printing paper P in the same manner. The nozzles Nz eject ink in accordance with image data Dn not only when they reach a position above the printing paper P but also when they reach a position beyond the edge of the printing paper P or a position above the left slot 26na or right slot 26nb. The image area (expanded area) of the image data Dn extends beyond the left and right edges of the printing paper P but fits between the side walls of the exterior portions of the left slot 26na and right slot 26nb. For this reason, ink droplets can be ejected in accordance with the image data Dn when the nozzles are disposed outside the printing paper P above the left slot 26na or right slot 26nb.

[0107]

Such printing allows images to be formed without blank spaces along the right and left edges of the printing paper P even when the printing paper P is shifted somewhat in the main scanning direction. Because the nozzles for printing images in the two side-edge portions of the printing paper are disposed above the left slot 26na or right slot 26nb, ink droplets deposit in the left slot 26na or right slot 26nb rather than in the central portion 26c of the platen 26

when shifted away from the printing paper P. It is therefore possible to prevent situations in which the printing paper P is soiled by the deposition of ink droplets in the central portion 26c of the platen 26.

[0108]

## 5 F. Modifications

The present invention is not limited by the above-described embodiments or embodiments and can be implemented in a variety of ways as long as the essence thereof is not compromised. For example, the following modifications are possible.

10 [0109]

### F1. Modification 1

The first, second, and third embodiments involved performing constant feeding in 1-, 3-, and 6-dot increments, respectively, in accordance with upper- and lower-edge routines. However, the feeding method of the upper- and lower-edge routines is not limited thereby and may include constant feeding in 2-, 4-, or 5-dot increments, depending on the nozzle pitch or the number of nozzles in a nozzle row. In other words, any feeding method may be adopted as long as the maximum feed increment in the sub-scanning direction is less than the maximum feed increment in the sub-scanning direction for the intermediate routine. It should be noted that adopting smaller feed increments in the sub-scanning direction for the upper-edge routine allows the upper edge of printing paper to be recorded with the nozzles disposed further downstream in the sub-scanning direction. The downstream slot can therefore be narrowed, and the upper platen surface for supporting the printing paper can be broadened. Similarly, adopting smaller feed increments in the sub-scanning direction for the lower-edge routine allows the upper edge of printing paper to be recorded with the nozzles disposed further upstream in the sub-scanning direction. The upstream slot can therefore be narrowed, and the upper platen surface for supporting the printing paper can be broadened.

[0110]

Neither is the feeding method of the intermediate routine limited to constant feeding in 11-dot increments, constant feeding in 24-dot increments, or an non-constant feeding arrangement in which the system is repeatedly fed in 5-, 2-, 3-, and 6-dot increments in the order indicated. For example, feeding the system in 5-, 3-, 2-, and 6-dot increments may be adopted for the structure described in the first embodiment. Depending on the number of nozzles, the nozzle pitch, or the like, combinations of other feed increments may be adopted, or constant feeding methods involving other feed increments carried out. In other words, any type of secondary scan feeding may be adopted as long as the maximum feed increment in the sub-scanning direction is less than the maximum feed increment in the sub-scanning direction for the upper or lower-edge routine.

[0111]

## F2. Modification 2

The above-described embodiments were configured such that the images provided beyond the edges of printing paper extended over two raster lines along both the upper and lower edges in the first embodiment, and constituted 16 raster lines along the upper edge and 30 raster lines along the lower edge in the second embodiment. In the third embodiment, the images extend over 30 raster lines along the upper edge and 40 raster lines along the lower edge. The images that extend beyond the edges of printing paper are not limited by these dimensions, however. For example, the width of the portion occupied by the image data D for an area lying outside the printing paper P beyond the upper edge Pf of the printing paper P may be half that of the downstream slot 26r. Similarly, the width of the portion occupied by the image data D for an area lying outside the printing paper P beyond the lower edge Pr of the printing paper P may be half that of the upstream slot 26f. In other words, the width of the portion occupied by the image data for an area lying outside a printing paper

beyond either edge should be less than the width of the downstream slot 26r along the upper edge, and less than the width of the upstream slot 26f along the lower edge. Adopting this arrangement makes it possible to prevent the ink droplets 1p for recording the images lying beyond a printing paper P from being deposited on the upper surface of the platen 26 when the ends of the printing paper P fail to reach the intended position. Approximately the same amount of shift can be permitted both in cases in which the printing paper P is shifted upstream and in cases in which the paper is shifted downstream, assuming that the affected area is about half the slot width.

[0112]

The same applies to the right and left edges. That is, the width of the portion occupied by the image data for an area lying outside a printing paper beyond either edge should be less than the width of the left slot 26na or the right slot 26nb. Approximately the same amount of shift can be permitted both in cases in which the printing paper P is shifted upstream and in cases in which the paper is shifted downstream, assuming that the affected area is about half the slot width.

[0113]

#### F3. Modification 3

Although the above embodiments were described with reference to cases in which both the upper- and lower-edge routine were carried out, it is also possible to perform only one of these routines as needed. In addition, the printing devices of the present embodiments were configured such that the platen 26 was provided with an upstream slot 26f and a downstream slot 26r on the upstream side and downstream sides, respectively, in the sub-scanning direction, although providing only one of them is also acceptable.

[0114]

#### F4. Modification 4

In the above embodiments, software can be used to perform some of the functions carried out by hardware, or, conversely, hardware can be used to perform some of the functions carried out by software. For example, a host computer 90 can be used to perform some of the functions carried out by the CPU 41 (Fig. 5).

[0115]

The computer programs for performing such functions may be supplied as programs stored on floppy disks, CD-ROMs, and other types of computer-readable recording media. The host computer 90 may read the computer programs from these recording media and transfer the data to internal or external storage devices. Alternatively, the computer programs can be installed on the host computer 90 from a program-supplying device via a communications line. Computer programs stored by an internal storage device are executed by the host computer 90 when the functions of the computer programs are to be performed. Alternatively, computer programs stored on a storage medium may be executed directly by the host computer 90.

[0116]

As used herein, the term "host computer 90" refers both to a hardware device and to an operating system, and designates a hardware device capable of operating under the control of an operating system. Computer programs allow such a host computer 90 to perform the functions of the above-described units. Some of the aforementioned functions can be performed by an operating system rather than an application program.

[0117]

As used herein, the term "computer-readable recording medium" is not limited to a portable recording medium such as a floppy disk or a CD-ROM and includes various RAMs, ROMs, and other internal computer storage devices as well as hard disks and other external storage devices fixed to the computer.

#### **[BRIEF DESCRIPTION OF THE DRAWINGS]**

[Fig. 1]

a side view depicting the structure of the periphery of a print head for an ink-jet printer configured according to an embodiment of the present invention;

[Fig. 2]

5 a diagram depicting the manner in which images are printed on the rear edge Pr of printing paper P;

[Fig. 3]

a block diagram depicting the structure of an image processing device and a printing device as embodiments of the present invention;

10 [Fig. 4]

a block diagram depicting the structure of the software for the present printing device;

[Fig. 5]

15 a diagram depicting the structure of the mechanical portion of the present printing device;

[Fig. 6]

a plan view depicting the arrangement of the nozzle units of each color in a print head unit 60;

[Fig. 7]

20 plan view depicting the periphery of a platen 26;

[Fig. 8]

a diagram depicting the manner in which raster lines are recorded by particular nozzles in an area near the front edge (tip) of printing paper;

[Fig. 9]

25 a plan view depicting the relation between image data D and printing paper P;

[Fig. 10]

a side view depicting the relation between print head 28 and printing paper P at the start of printing;

[Fig. 11]

a side view depicting the relation between print head 28 and printing paper P at the start of printing according to a comparative example;

[Fig. 12]

5 a diagram depicting the manner in which raster lines are recorded by particular nozzles during a lower-edge routine;

[Fig. 13]

a plan view depicting the relation between the printing paper P and an upstream slot 26f during printing in the lower-edge portion Pr of the printing  
10 paper P;

[Fig. 14]

a side view depicting the relation between the printing paper P and print head 28 during printing along the lowermost edge of the printing paper;

[Fig. 15]

15 a side view depicting the relation between the print head 28 and printing paper P when the lowermost edge of the printing paper is printed according to a comparative example;

[Fig. 16]

a side view depicting the relation of a print head 28a with an upstream slot  
20 26fa and a downstream slot 26ra according to a second embodiment;

[Fig. 17]

a diagram depicting the manner in which raster lines are recorded by particular nozzles during the upper-edge routine of the second embodiment;

[Fig. 18]

25 a diagram depicting the manner in which raster lines are recorded by particular nozzles during the upper-edge routine of the second embodiment;

[Fig. 19]

a diagram depicting the manner in which raster lines are recorded by particular nozzles during the lower-edge routine of the second embodiment;



[Fig. 20]

a diagram depicting the manner in which raster lines are recorded by particular nozzles during the lower-edge routine of the second embodiment;

[Fig. 21]

5 a side view depicting the relation of a print head 28b with an upstream slot 26fb and a downstream slot 26rb according to a third embodiment;

[Fig. 22]

a diagram depicting the arrangement of ink-jet nozzles Nz in the ink-injecting heads 61b–66b pertaining to the third embodiment;

10 [Fig. 23]

a diagram depicting the manner in which raster lines are recorded by particular nozzles during the upper-edge routine of the third embodiment;

[Fig. 24]

15 a diagram depicting the manner in which raster lines are recorded by particular nozzles during the upper-edge routine of the third embodiment;

[Fig. 25]

a diagram depicting the manner in which raster lines are recorded by particular nozzles during the lower-edge routine of the third embodiment;

[Fig. 26]

20 a diagram depicting the manner in which raster lines are recorded by particular nozzles during the lower-edge routine of the third embodiment;

[Fig. 27]

a plan view depicting the relation between image data Dn and printing paper P;

25 [Fig. 28]

a plan view depicting the periphery of a platen 26n for a printer 22n;

[Fig. 29]

a diagram depicting the manner in which images are printed in the left and right side-edge portions of the printing paper P;

[Fig. 30]

a side view depicting the periphery of a print head for a conventional printer.

**[Description of the Symbols]**

- |    |   |
|----|---|
| 5  | 12 ... scanner                            |
|    | 14 ... keyboard                           |
|    | 15 ... floppy drive                       |
|    | 16 ... hard disk                          |
|    | 18 ... modem                              |
| 10 | 21 ... CRT                                |
|    | 22, 22n ... printer                       |
|    | 23 ... paper feed motor                   |
|    | 24 ... carriage motor                     |
|    | 25a, 25b ... upstream paper feed roller   |
| 15 | 25c, 25d ... downstream paper feed roller |
|    | 25p, 25q ... upstream paper feed roller   |
|    | 25r, 25s ... downstream paper feed roller |
|    | 26, 26a, 26b, 26n, 26o ... platen         |
|    | 26c ... central portion                   |
| 20 | 26f, 26fa, 26fb ... upstream slot         |
|    | 26na ... left slot                        |
|    | 26nb ... right slot                       |
|    | 26r, 26ra, 26rb ... downstream slot       |
|    | 27, 27f, 27r ... absorbent member         |
| 25 | 28, 28a, 28b, 28o ... print head          |
|    | 29a, 29b ... guide                        |
|    | 31 ... carriage                           |
|    | 32 ... control panel                      |
|    | 34 ... sliding shaft                      |

	36 ... drive belt
	38 ... pulley
	39 ... position sensor
	40 ... control circuit
5	41 ... CPU
	42 ... PROM
	43 ... RAM
	44 ... drive buffer
	45 ... PC interface
10	60 ... print head unit
	61-66 ... ink-injecting head
	61b-66b ... ink-injecting head
	67 ... introduction tube
	68 ... ink conduit
15	71 ... cartridge
	72 ... color-ink cartridge
	80 ... bus
	81 ... CPU
	82 ... ROM
20	83 ... RAM
	84 ... input interface
	85 ... output interface
	86 ... CRTC
	88 ... SIO
25	90 ... host computer
	91 ... video driver
	95 ... application program
	96 ... printer driver
	97 ... resolution conversion module

98 ... color correction module  
 99 ... halftone module  
 100 ... rasterizer  
 D, Dn ... image data  
 5 DT ... dot-forming pattern table  
 FD ... floppy disk  
 Ip ... ink particle  
 L31 ... distance for printing and secondary-scan feeding by upstream  
 paper feed rollers alone  
 10 L41 ... distance for printing and secondary-scan feeding by downstream  
 paper feed rollers alone  
 L32 ... distance for printing and secondary-scan feeding by upstream  
 paper feed rollers alone  
 L42 ... distance for printing and secondary-scan feeding by downstream  
 15 paper feed rollers alone  
 LUT ... color correction table  
 N1 ... group of nozzles used for upper-edge routine  
 N2 ... group of nozzles used for transitional routine  
 N3 ... group of nozzles used for intermediate routine  
 20 N4 ... group of nozzles used for intermediate routine  
 N5 ... group of nozzles used for lower-edge routine  
 Nf ... upstream group of nozzles  
 Nr ... downstream group of nozzles  
 Nz ... ink-jet nozzle  
 25 ORG ... primary-color image data  
 P ... printing paper  
 PD ... print data  
 PE ... piezoelement  
 PNT ... public telephone network

Pa ... left edge (portion)

Pb ... right edge (portion)

Pf ... upper edge (portion)

Pr ... lower edge (portion)

5 R26 ... range containing central portion of platen

Rf ... range containing upstream slot

Rr ... range containing downstream slot

SV ... server

k ... nozzle pitch

**[DOCUMENT NAME] ABSTRACT**

**[ABSTRACT]**

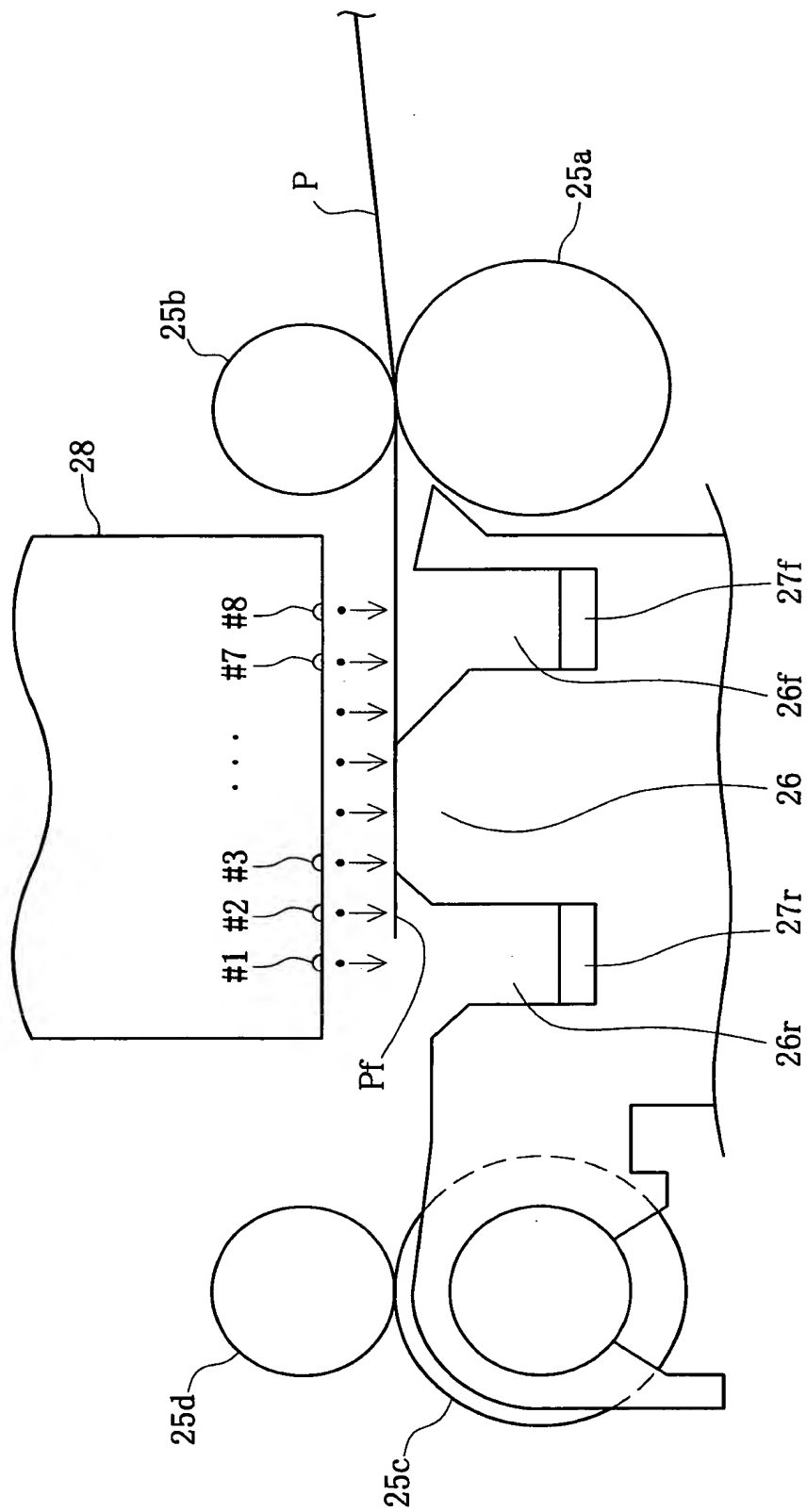
**[OBJECTIVE]** To allow images to be printed up to the edges of printing paper while preventing ink droplets from depositing on the platen

5 **[MEANS FOR PROBLEM SOLVING]** Ink droplets  $I_p$  are ejected from a print head 28 and printing is started when printing paper P is fed in the sub-scanning direction by upstream paper feed rollers 25a and 25b, and the front edge Pf reaches a position above a downstream slot 26r. Since printing is started when the front edge Pf of printing paper P has reached a position behind  
10 nozzle No. 1, images can be printed without forming blank spaces up to the front edge Pf of the printing paper P by causing the nozzles to eject ink droplets  $I_p$  irrespective of whether the nozzles are above the printing paper. When images are formed in the vicinity of the front edge Pf of printing paper P, the paper is repeatedly fed in small increments in the sub-scanning direction, and printing is  
15 carried out. Adopting this arrangement makes it possible to print images on the front-edge portion of the printing paper when the paper is above the downstream slot 26r.

**[SELECTED FIGURE]** Fig. 1

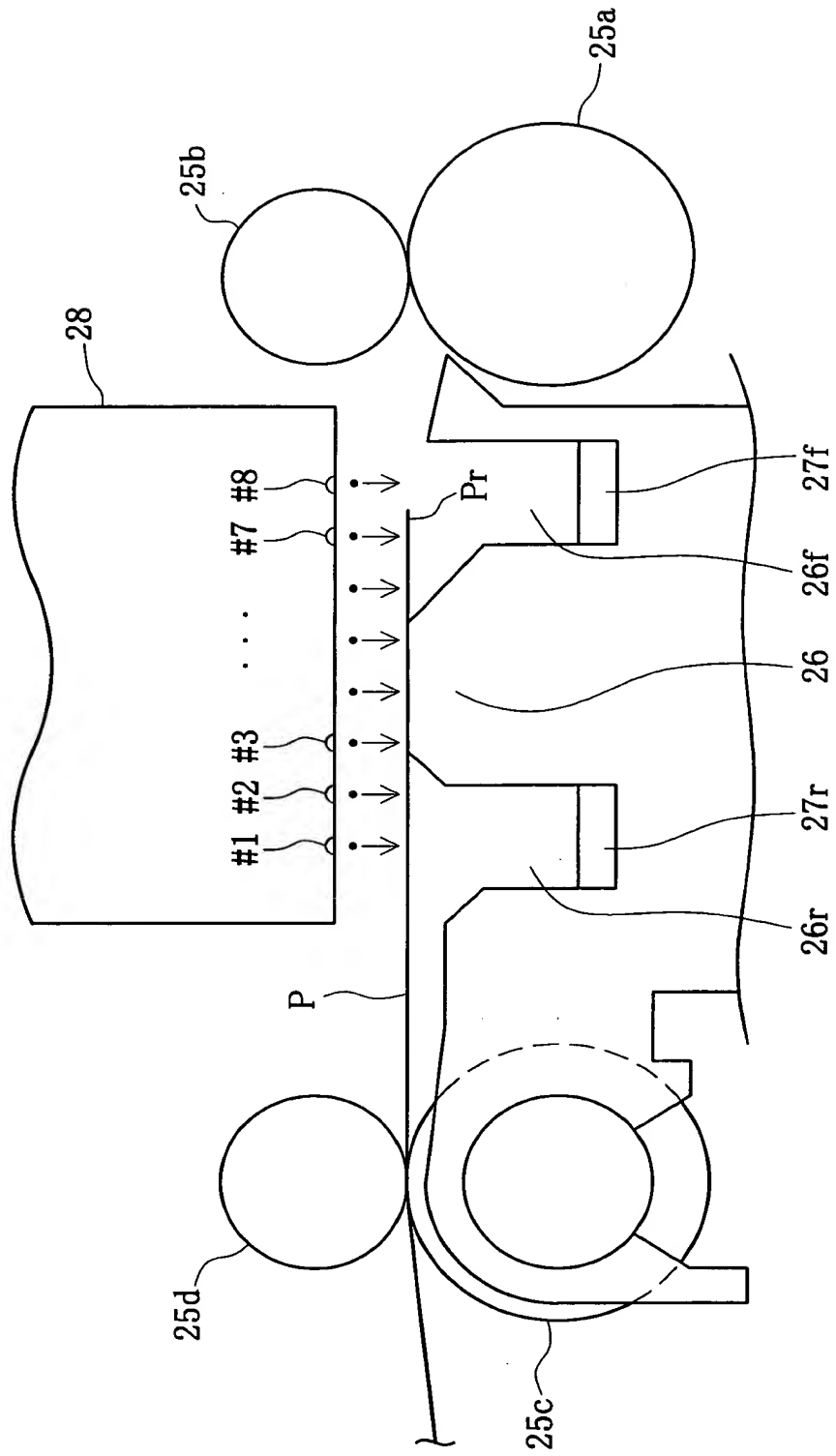


【DOCUMENT NAME】 DRAWINGS  
【Fig.1】





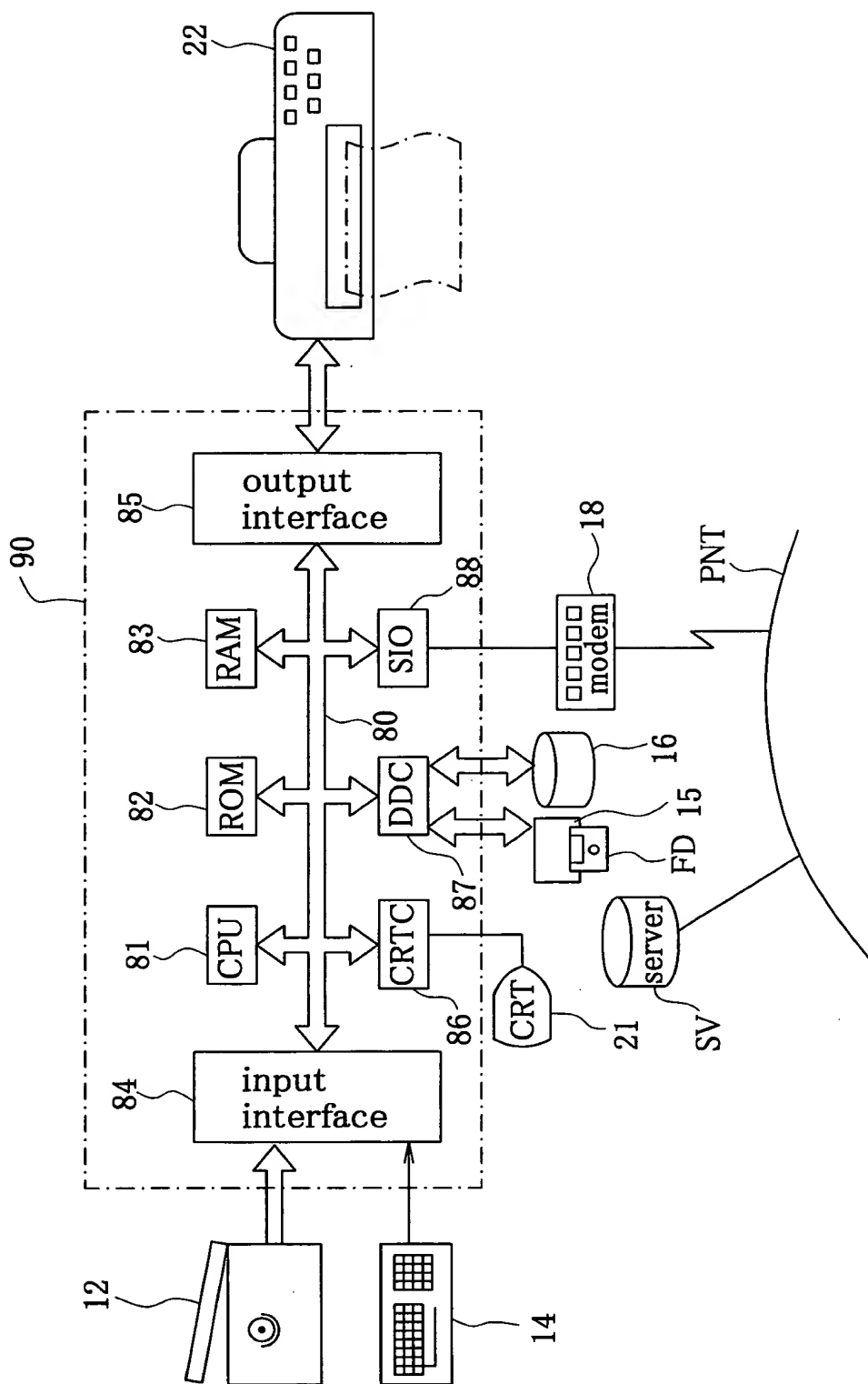
【Fig.2】





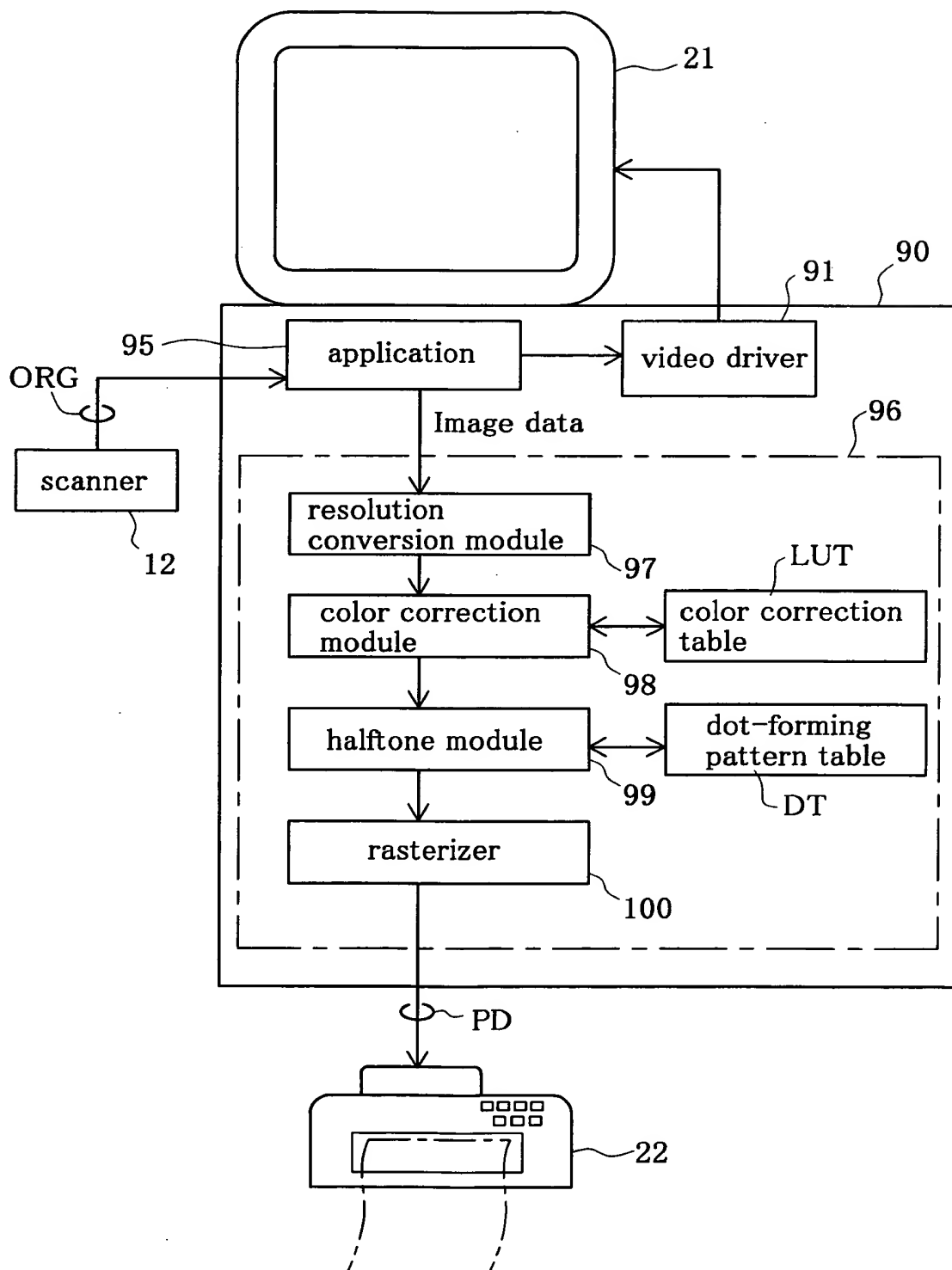


【Fig.3】

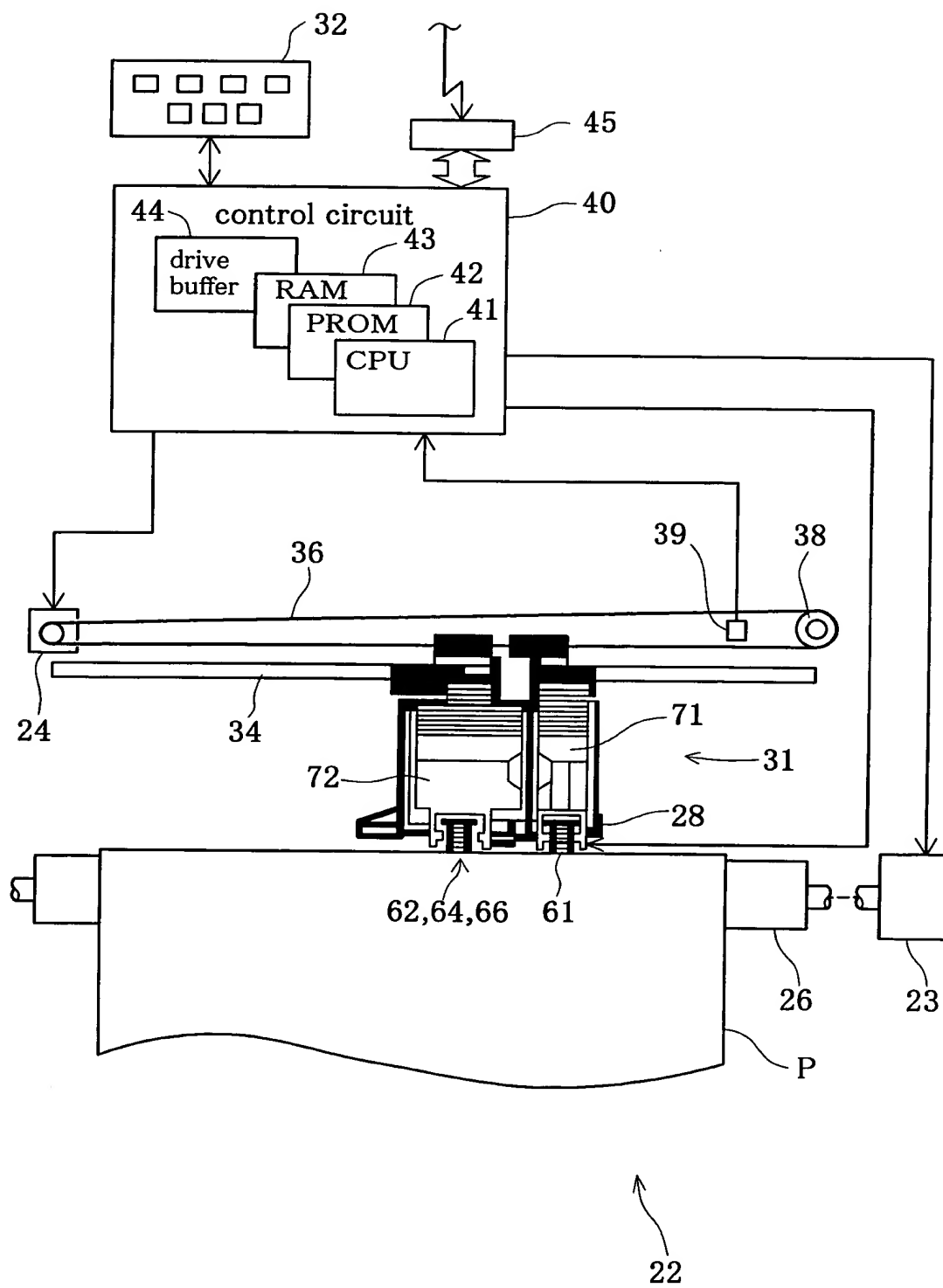


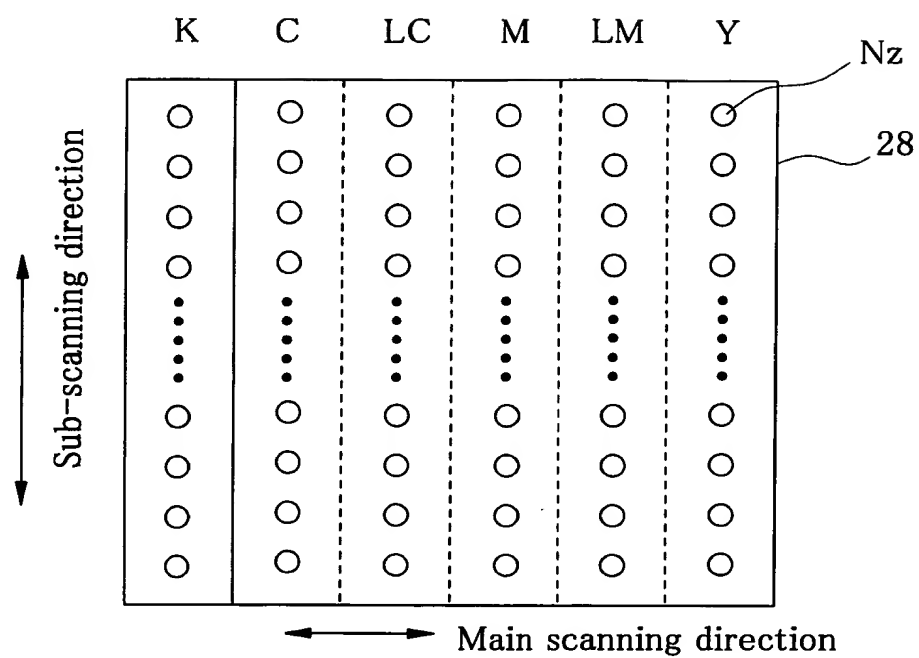
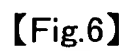


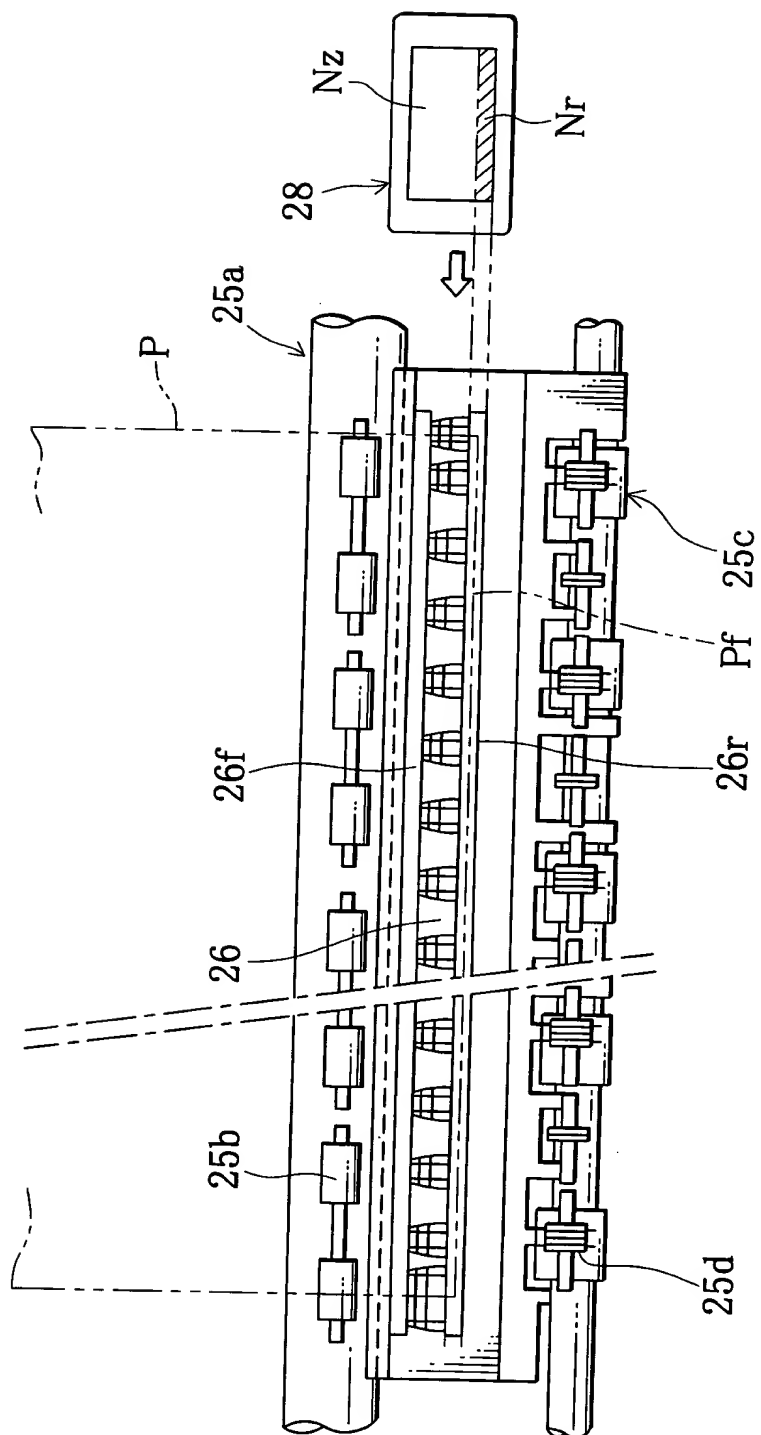
【Fig.4】



**【Fig.5】**

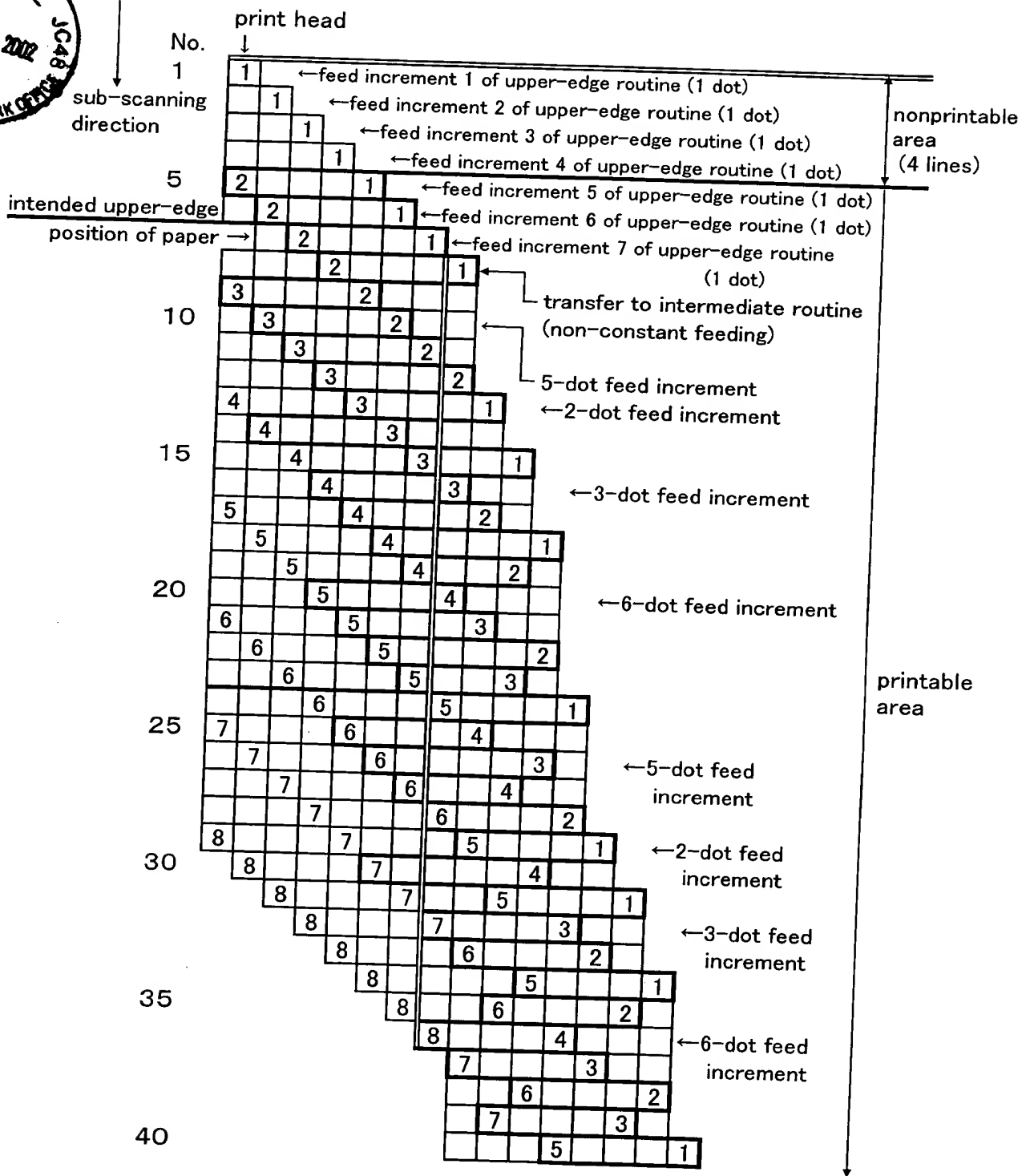






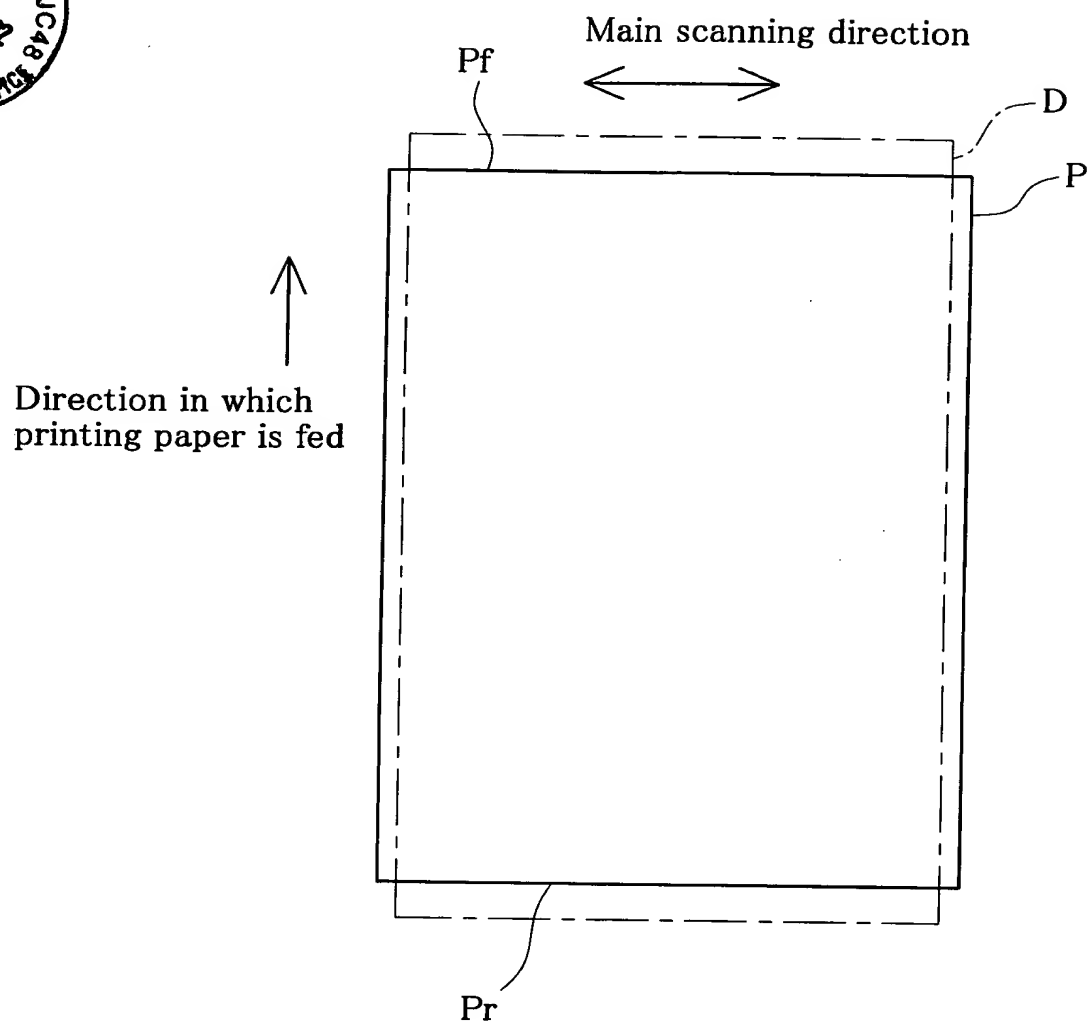
**【Fig. 7】**

【Fig.8】



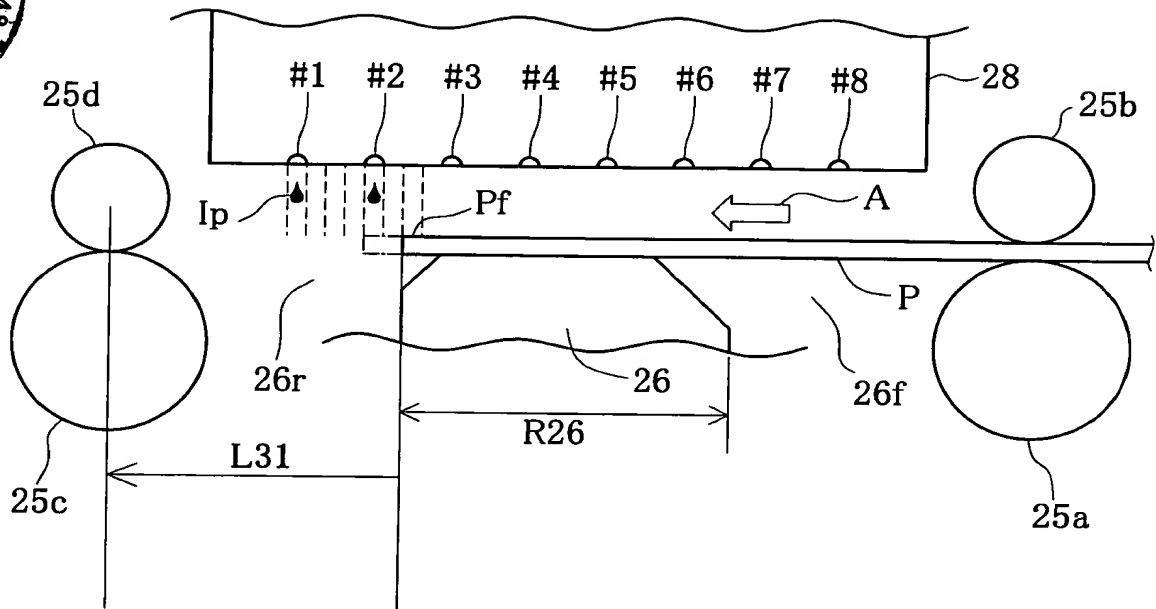


【Fig.9】

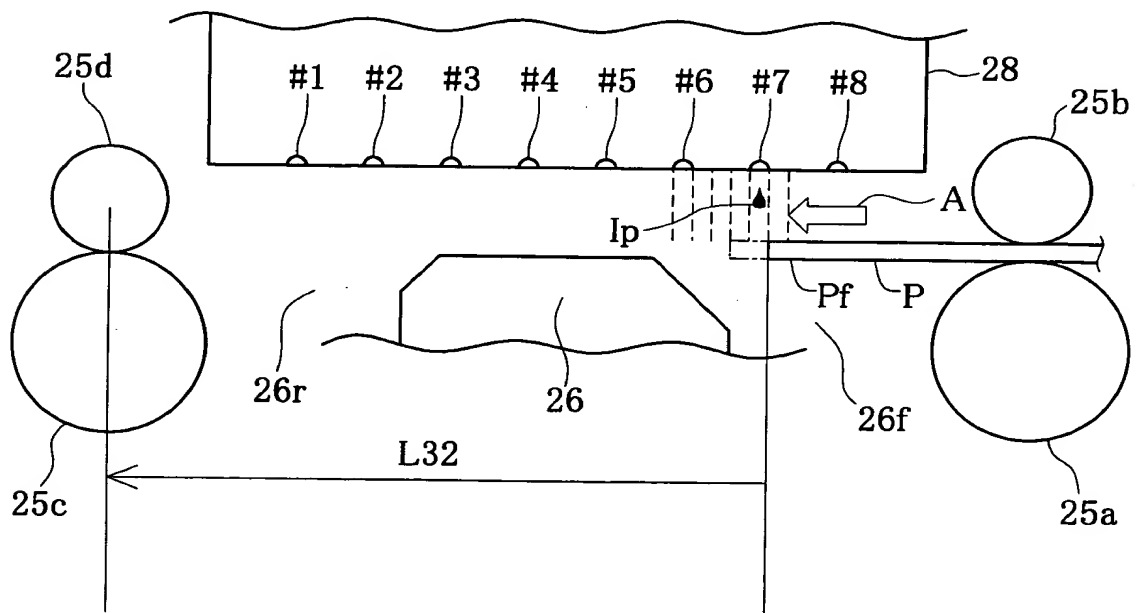




【Fig.10】

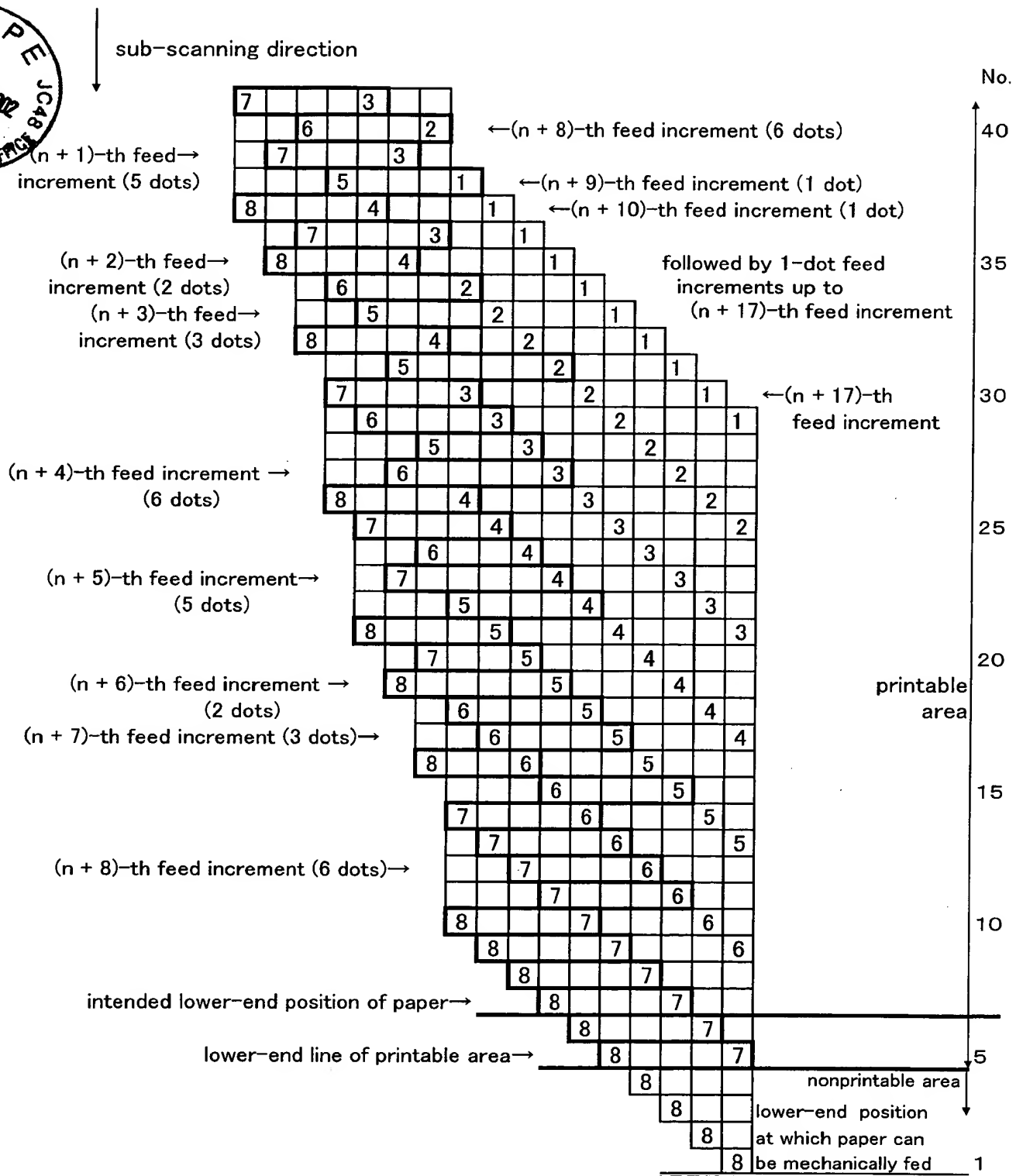


【Fig.11】



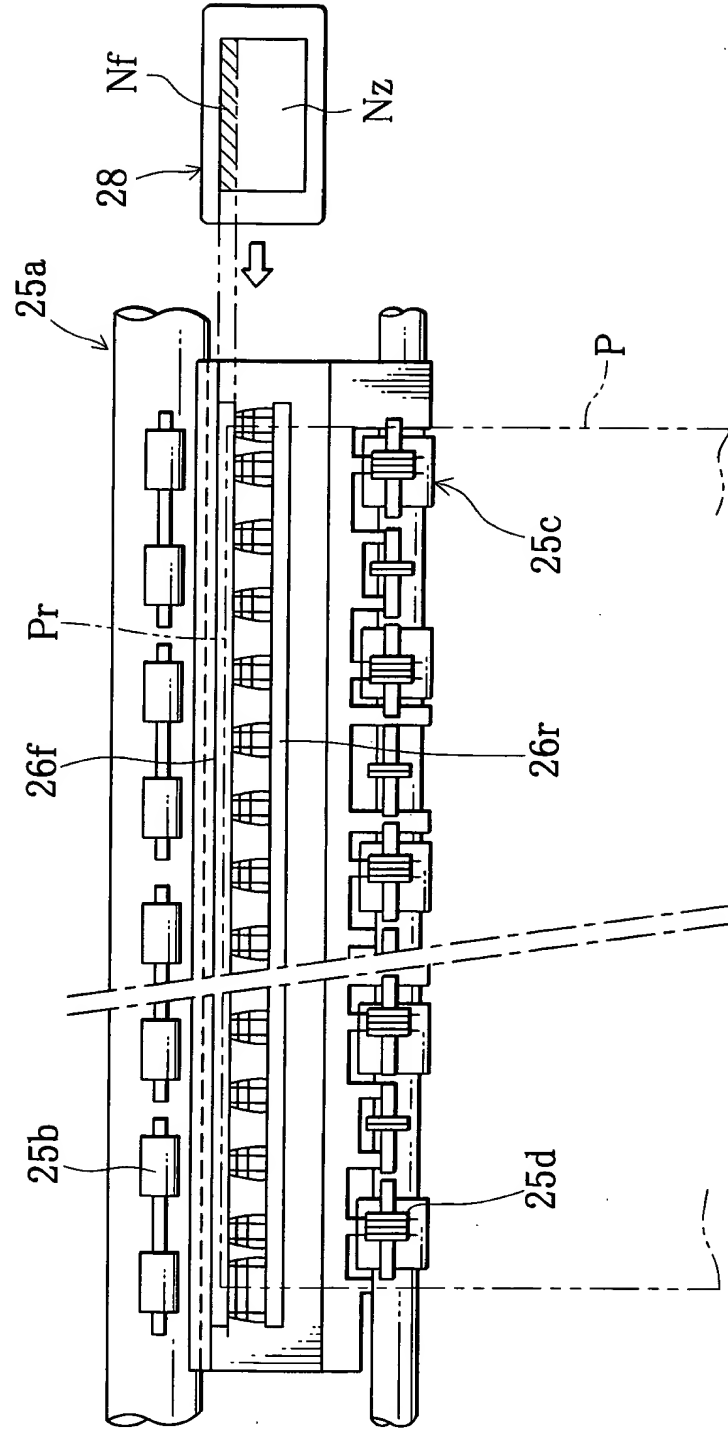


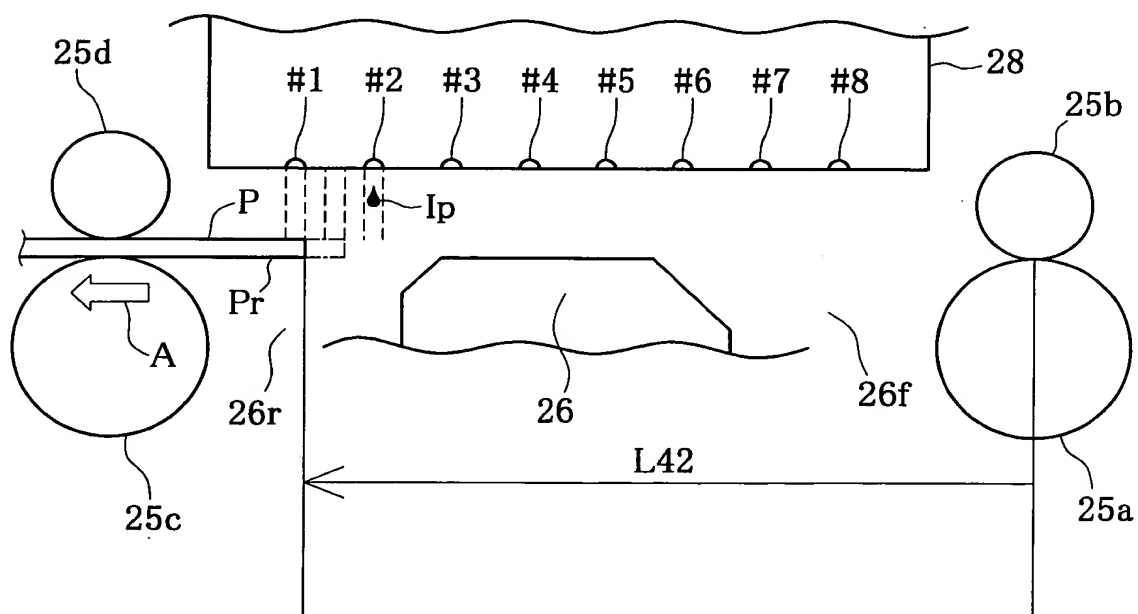
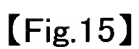
【Fig.12】





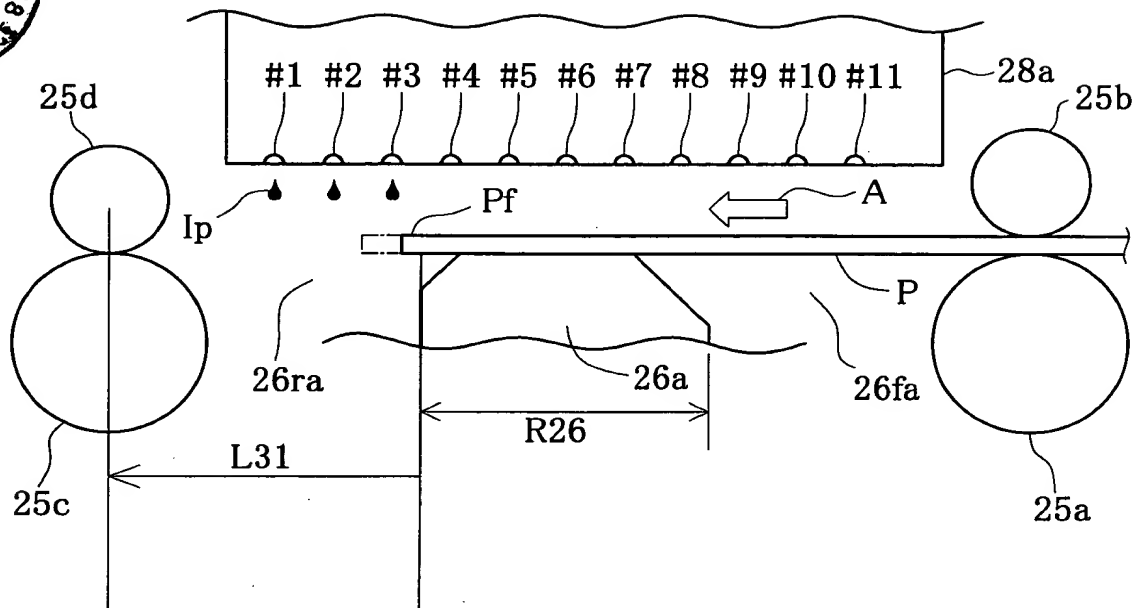
【Fig.13】



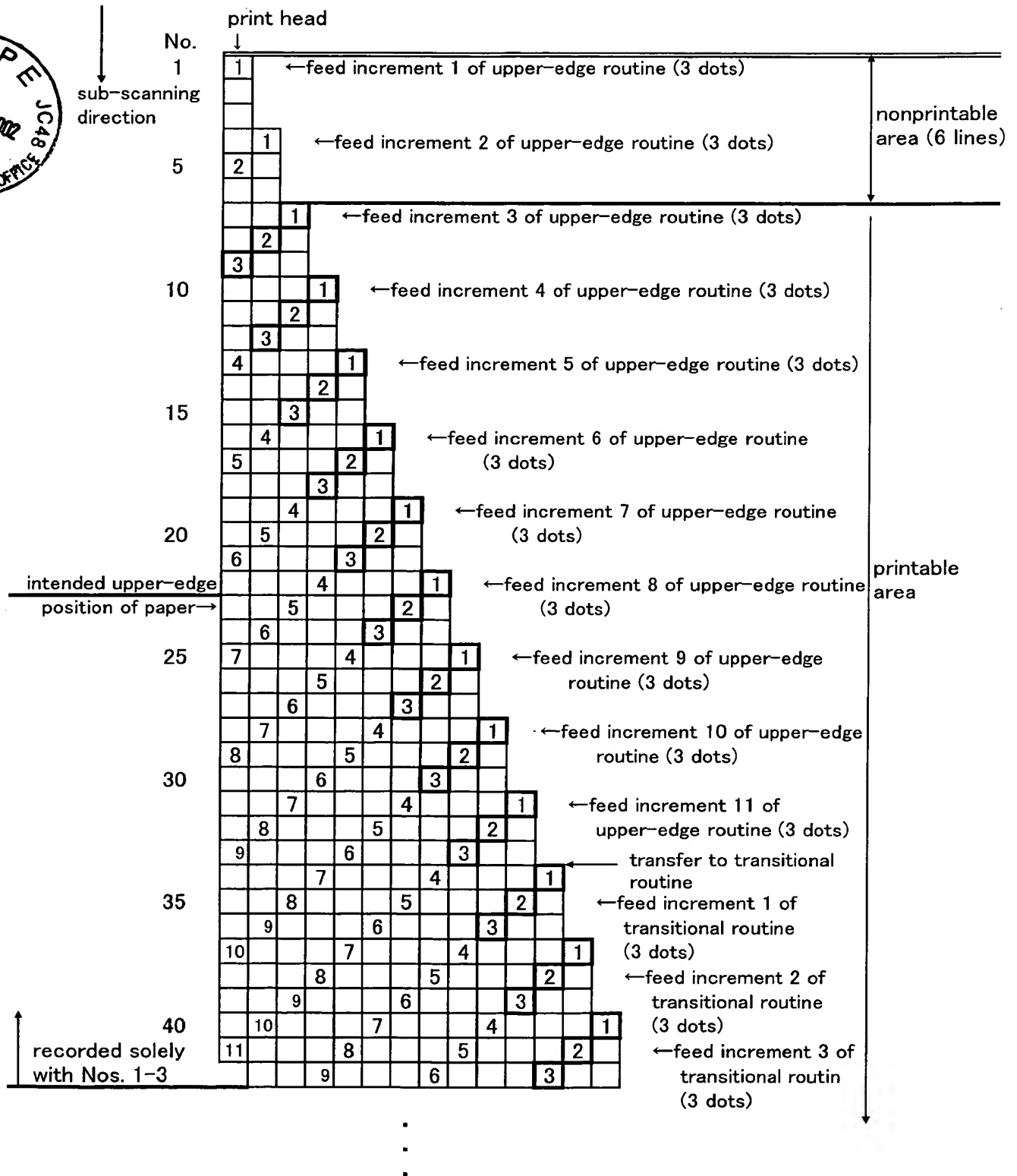




【Fig.16】



【Fig.17】



No.

45

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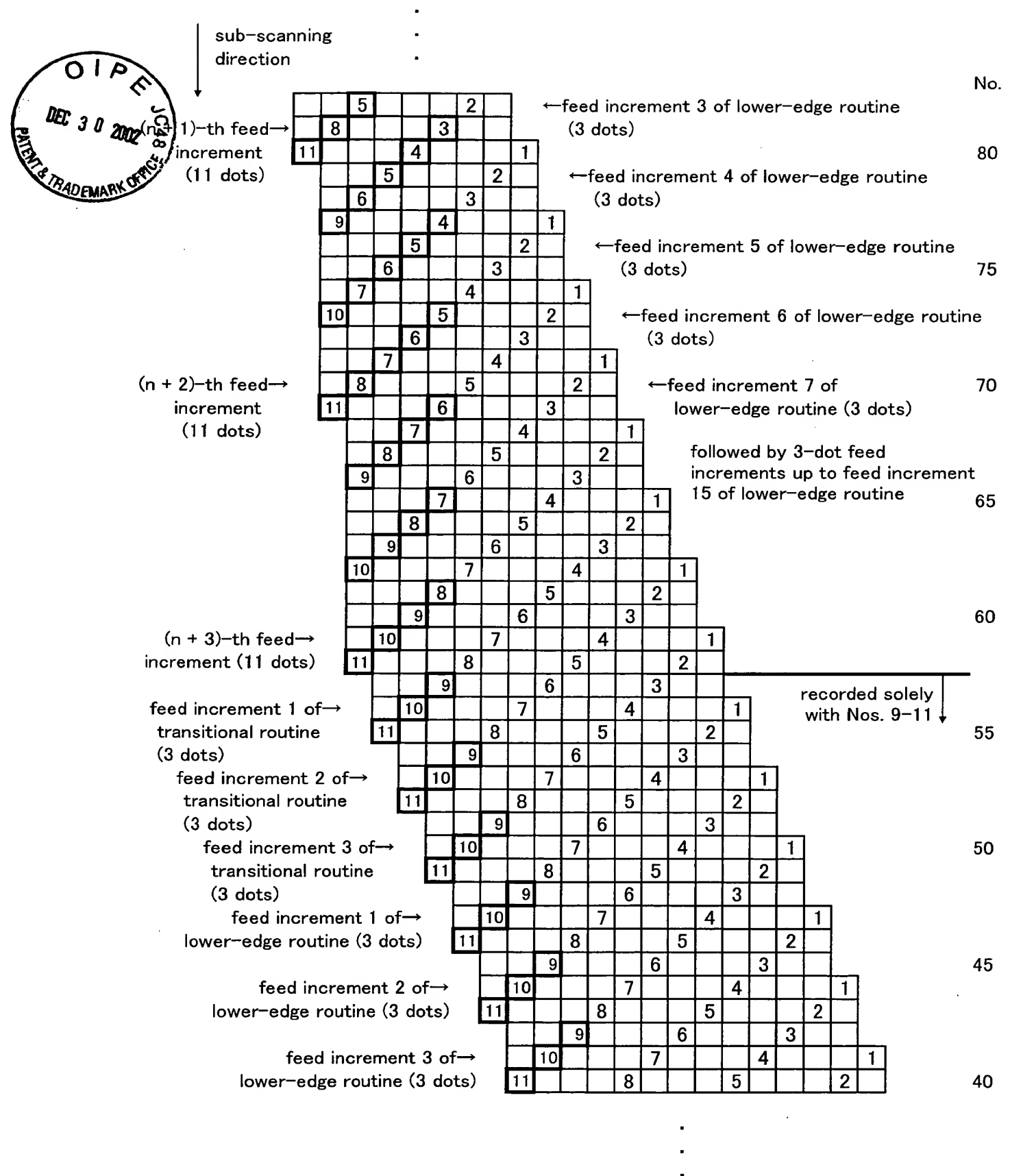
65

70

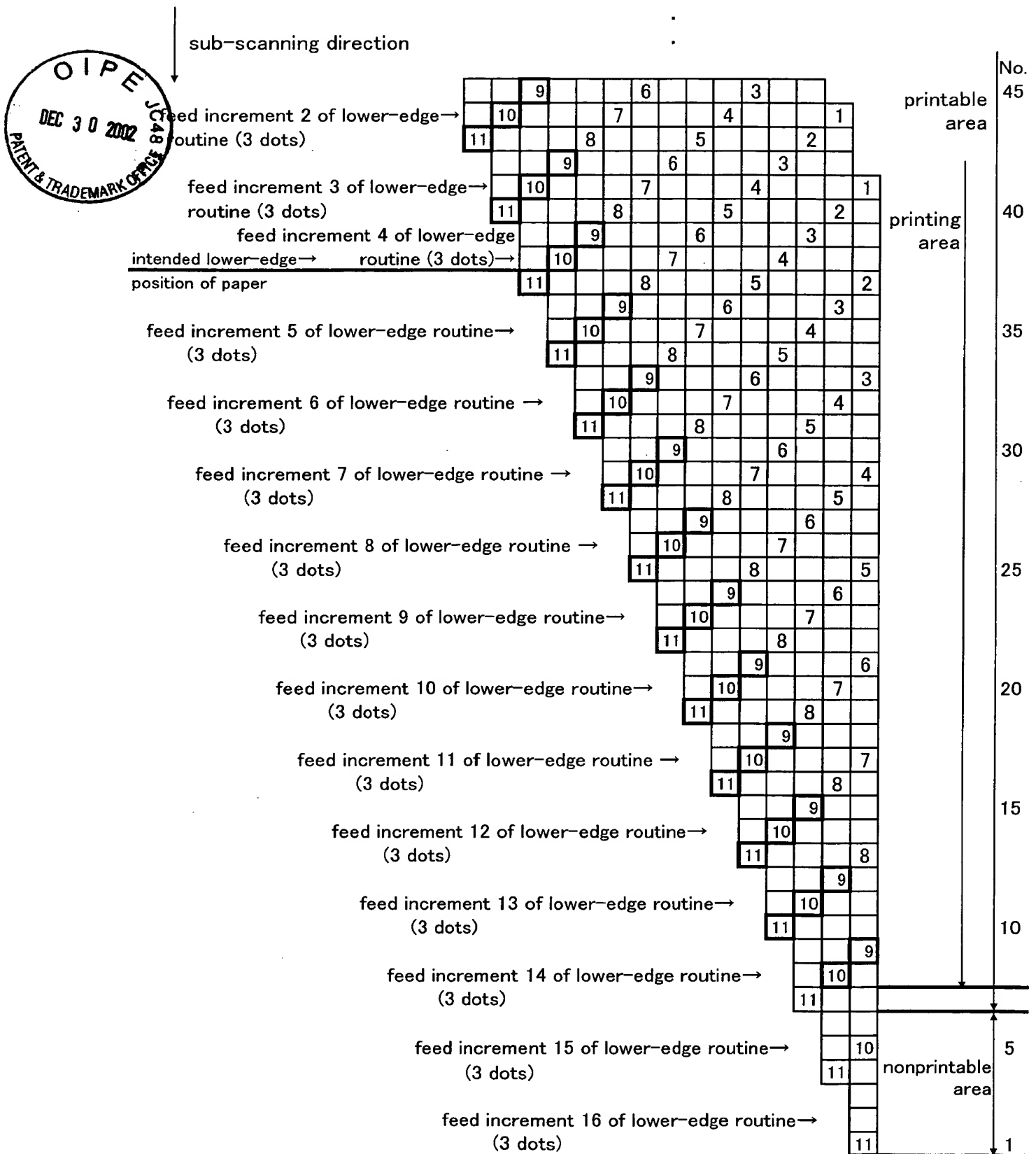
←11-dot feed  
increment

•

【Fig.19】

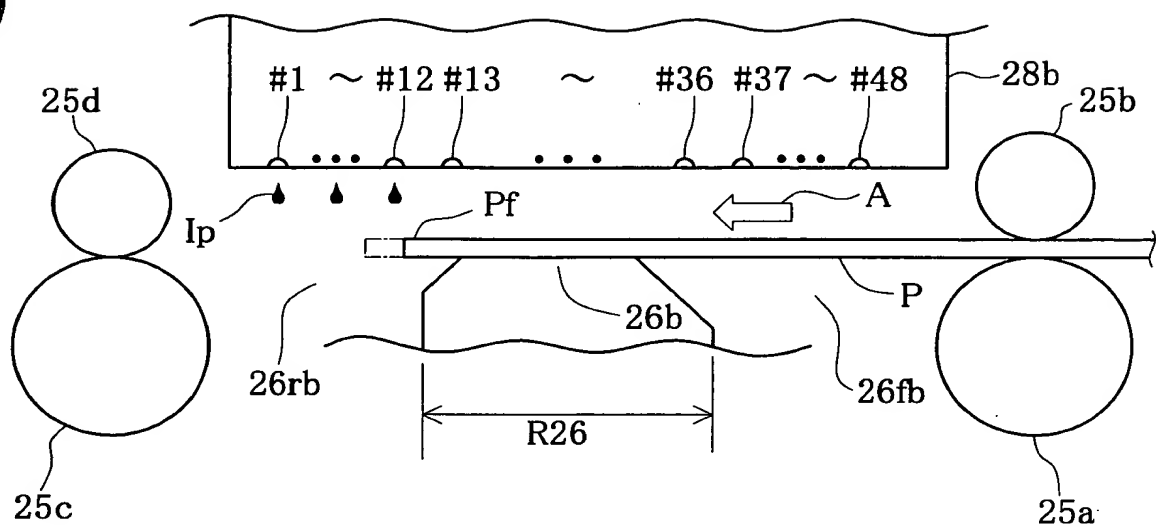


【Fig.20】

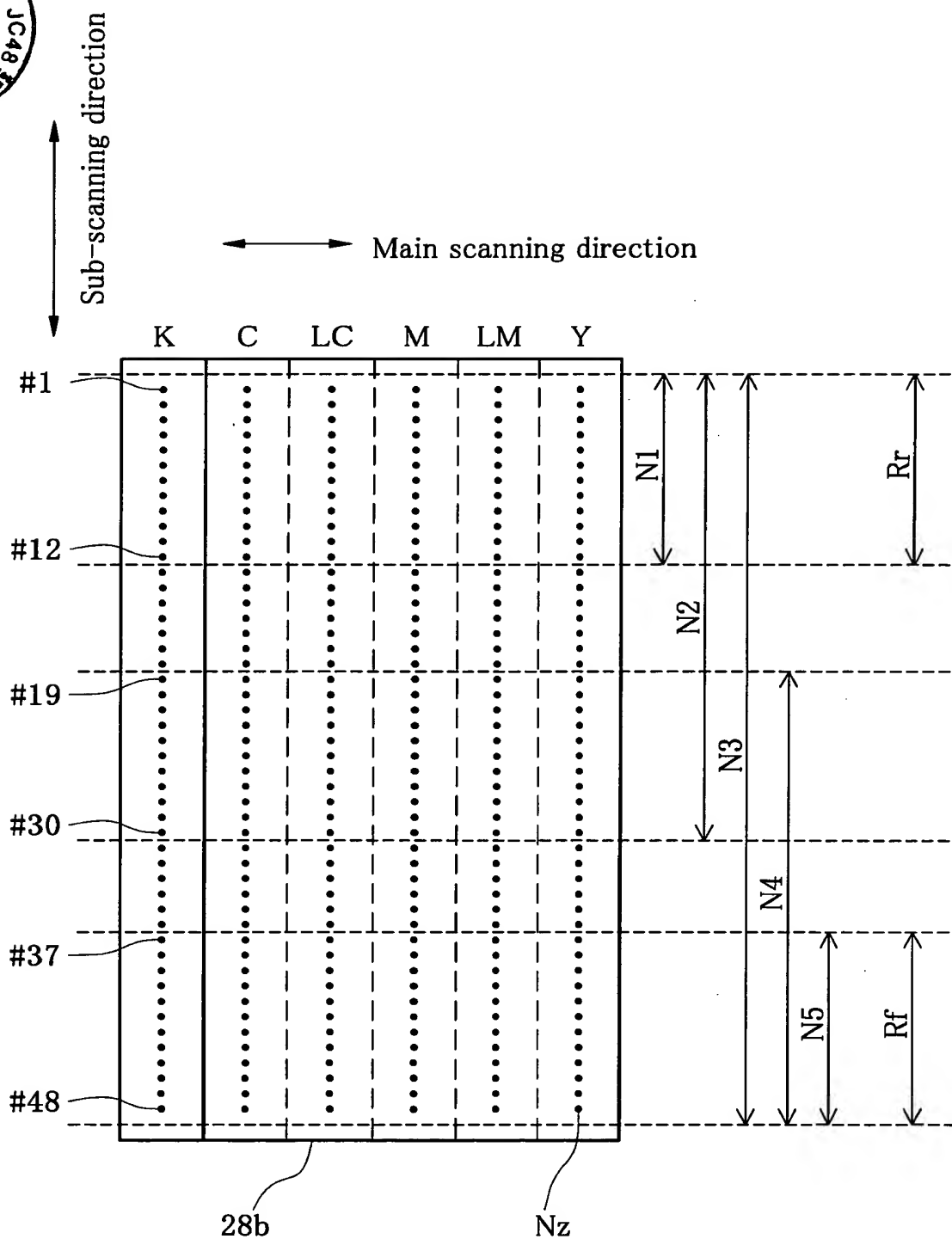




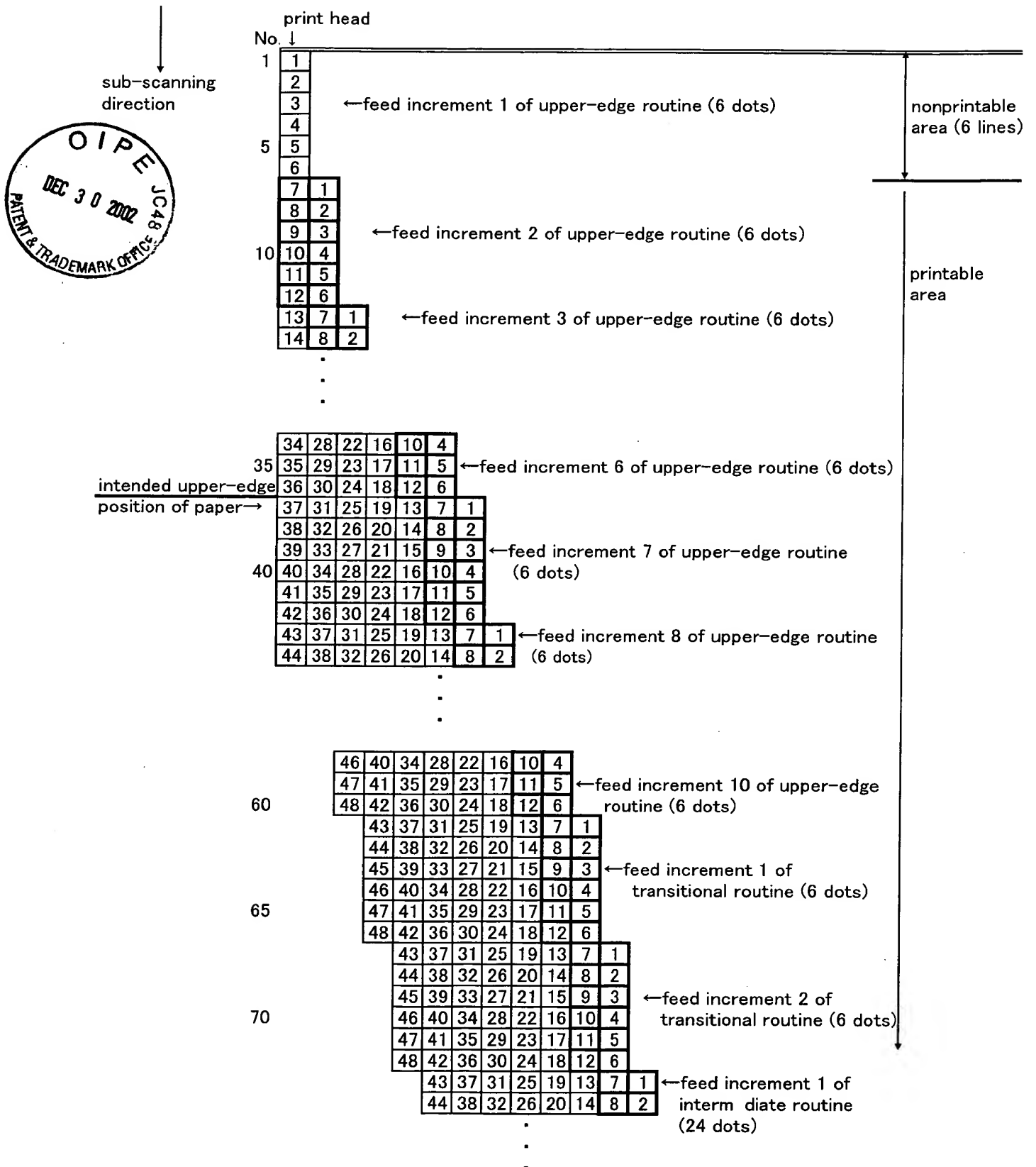
【Fig.21】



【Fig.22】



【Fig.23】



【Fig.24】

sub-scanning direction



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100

105

110

48	42	36	30	24	18	12	6
43	37	31	25	19	13	7	1
44	38	32	26	20	14	8	2
45	39	33	27	21	15	9	3
46	40	34	28	22	16	10	4
47	41	35	29	23	17	11	5
48	42	36	30	24	18	12	6

←feed increment 2 of transitional routine (6 dots)

43	37	31	25	19	13	7	1
44	38	32	26	20	14	8	2
45	39	33	27	21	15	9	3
46	40	34	28	22	16	10	4
47	41	35	29	23	17	11	5
48	42	36	30	24	18	12	6

←feed increment 1 of intermediate routine (24 dots)

43	37	31	25	19	13	7
44	38	32	26	20	14	8
45	39	33	27	21	15	9
46	40	34	28	22	16	10
47	41	35	29	23	17	11
48	42	36	30	24	18	12

43	37	31	25	19	13
44	38	32	26	20	14
45	39	33	27	21	15
46	40	34	28	22	16
47	41	35	29	23	17
48	42	36	30	24	18

43	37	31	25	19
44	38	32	26	20
45	39	33	27	21
46	40	34	28	22
47	41	35	29	23
48	42	36	30	24

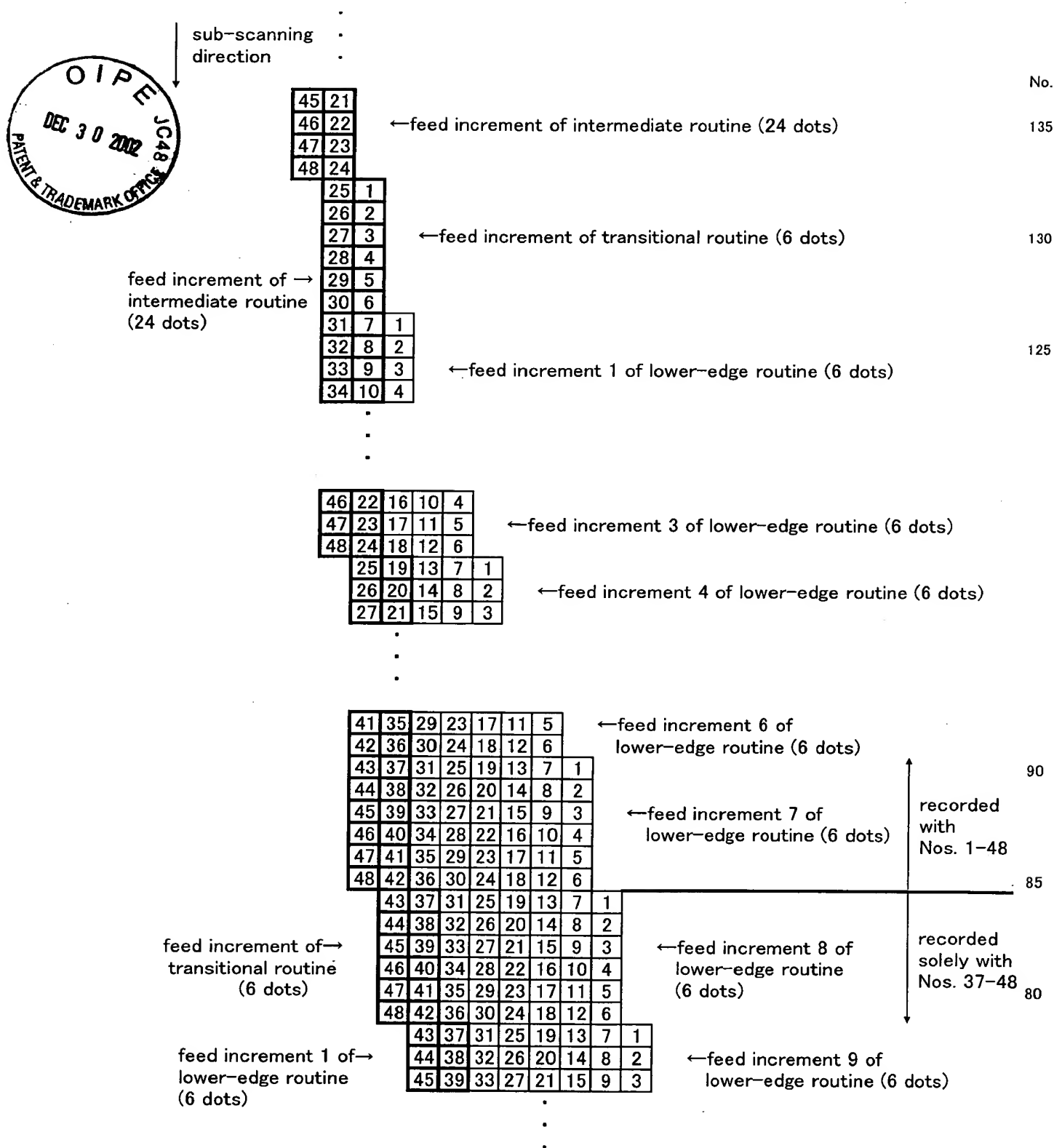
43	37	31	25	1
44	38	32	26	2
45	39	33	27	3
46	40	34	28	4
47	41	35	29	5
48	42	36	30	6

←feed increment 2 of intermediate routine (24 dots)

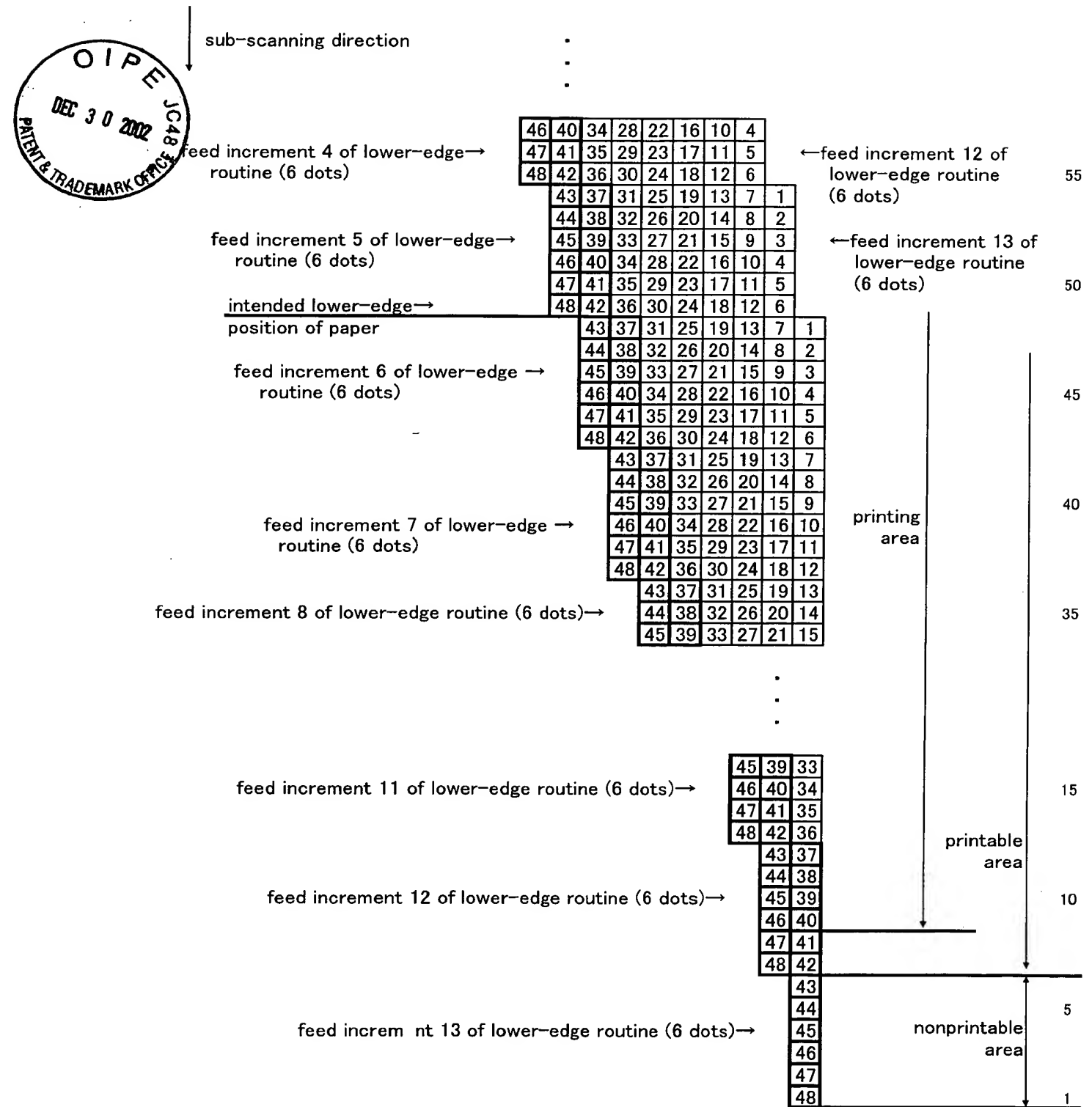
43	37	31	7
44	38	32	8
45	39	33	9
46	40	34	10
47	41	35	11
48	42	36	12

43	37	13
44	38	14
45	39	15

【Fig.25】

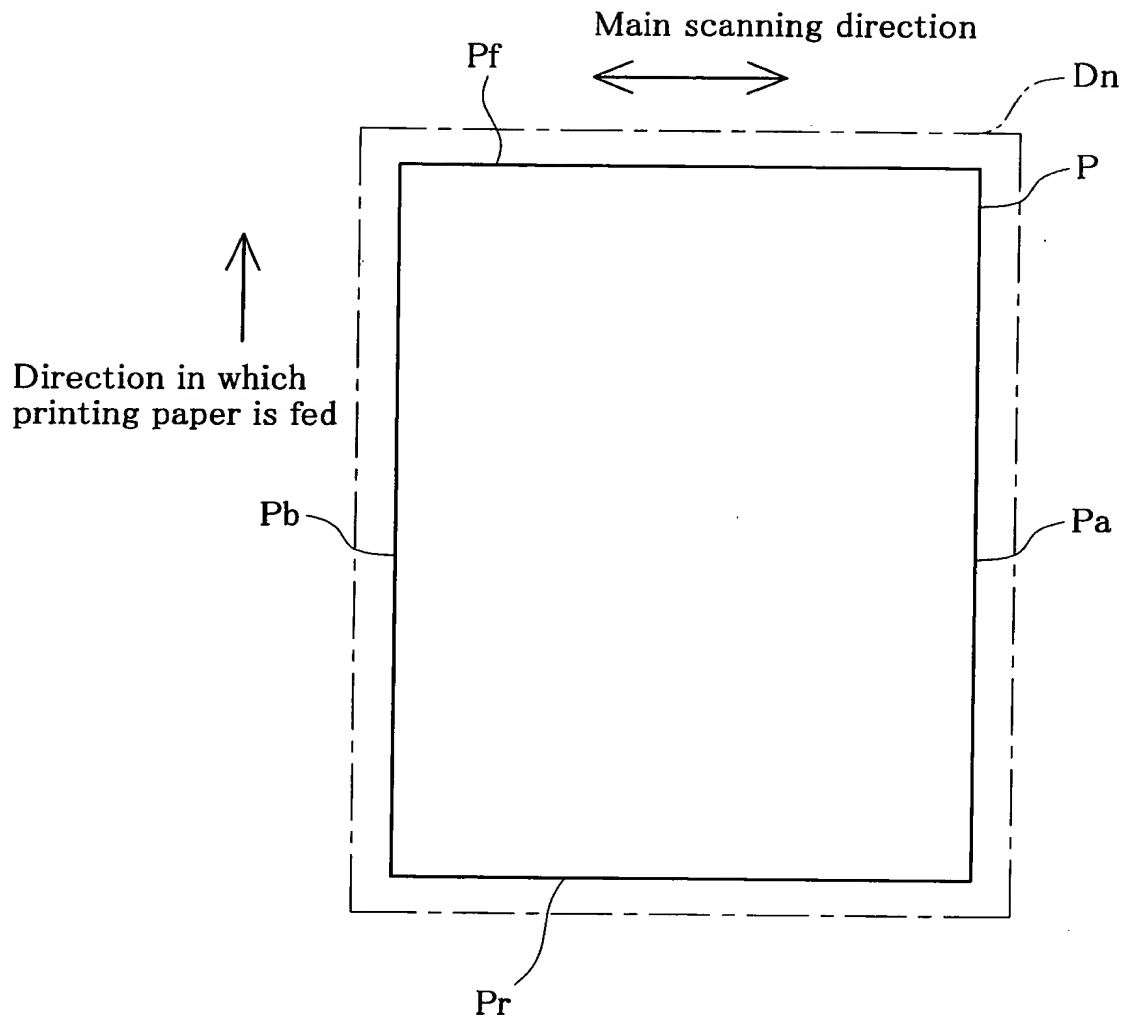


**【Fig.26】**



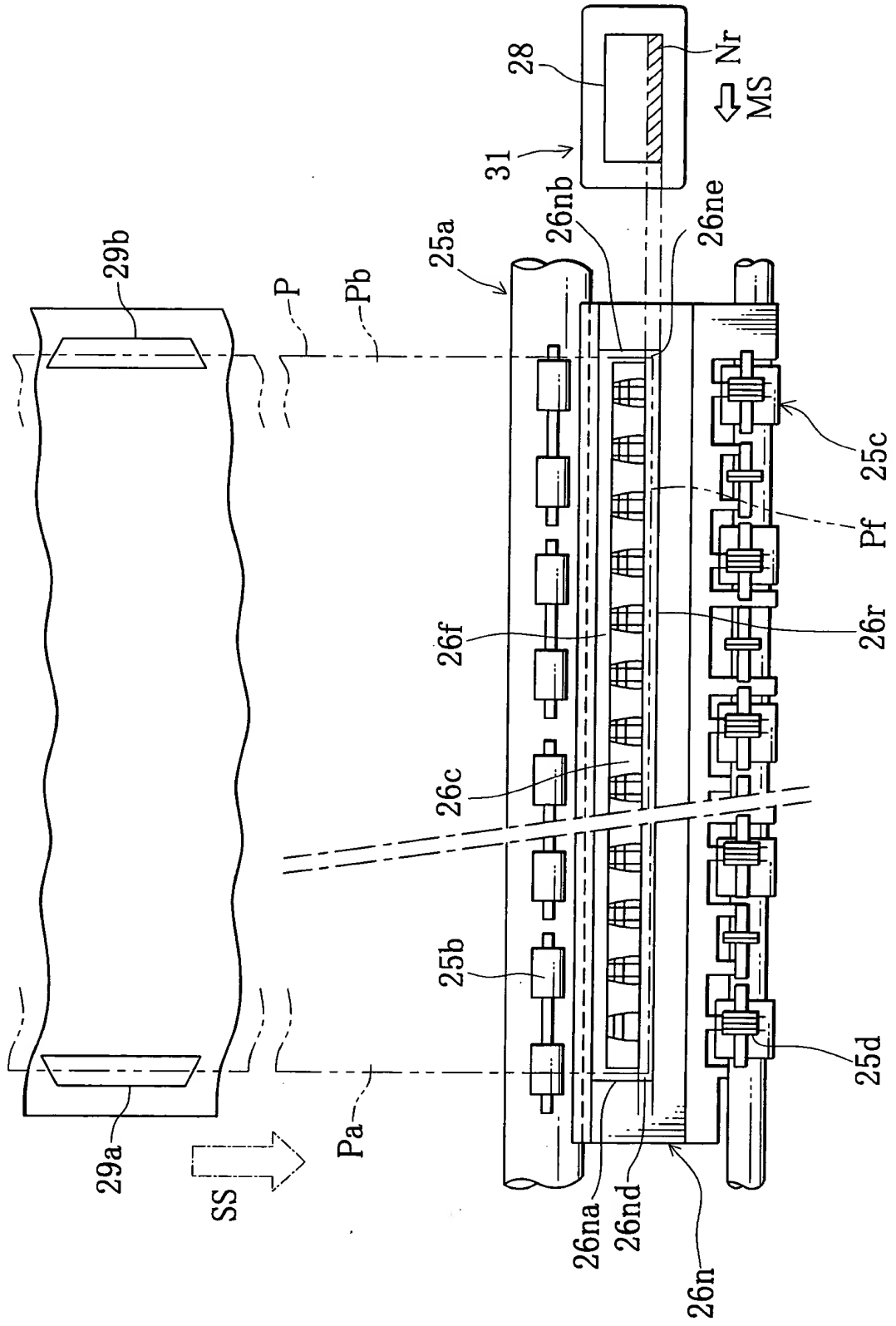


【Fig.27】





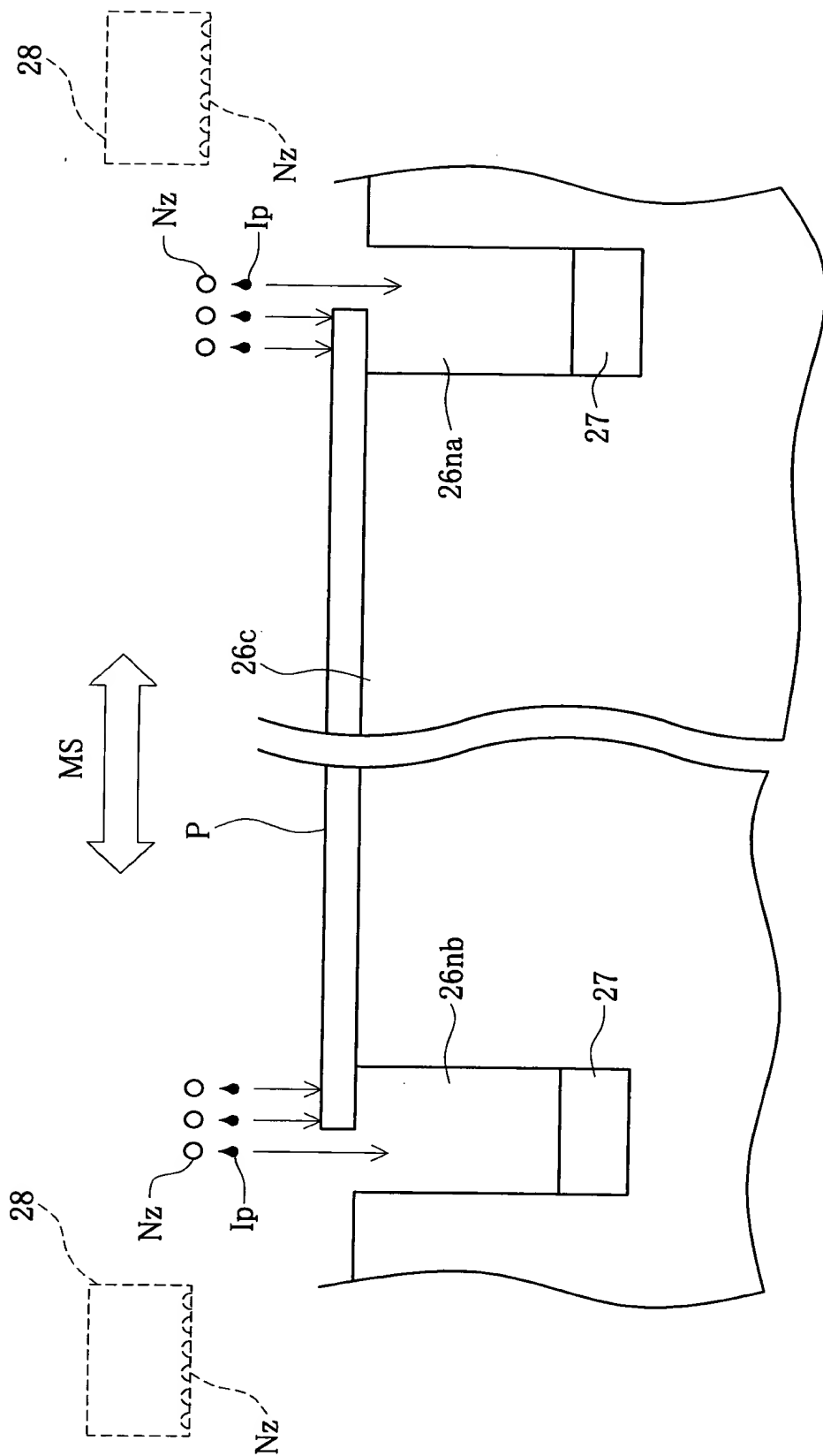
【Fig.28】







【Fig.29】





【Fig.30】

